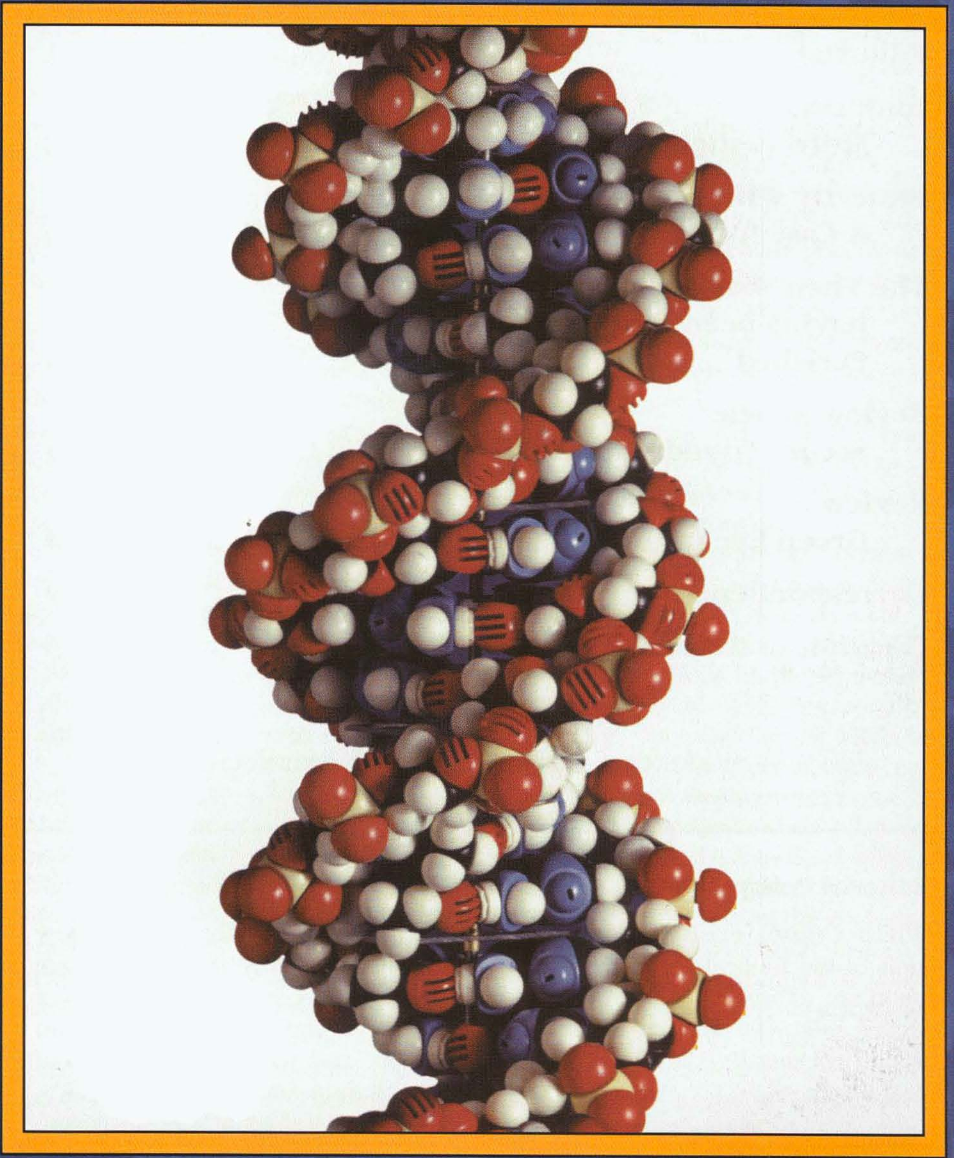
ORIGINS

The Journal of The Biblical Creation Society

No.29

November 2000

Why Butterflies are Beautiful



DNA – Junk debunked

Interpreting the Flood

Interaction of Science & Bible

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ORIGINS
• Journal of the Biblical Creation Society •

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A model of a portion of the DNA molecule

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Editorial

Time for change!

FOR SOME time we have been seeking your views on the future format of this journal. At last we have reached conclusions and, with this issue, we announce the plans which we hope will meet with your approval.

I have recently been reading some of our early publications. Our first journal was called *Biblical Creation*. The editorial of the second issue could almost have been written here as the editor was reacting to feelings that the previous copy had been found to be a bit heavy. (Mind you, it was not as technical as some recent articles in *Origins*!). He hoped that future issues would redress the balance. We are still learning! By the way, I was very encouraged in re-reading this early material and would commend the publications to you. Though stocks are low, we do still have some issues of *Biblical Creation* (and most of *Origins*) available at reduced prices.

So, what is our plan?

We have yet to finalise the program, but from this volume we will increase the amount of the popular level material carried in our journal. To facilitate this, we will have two editorial committees to oversee the production of technical and 'popular' material. The popular material will be designed for the non-specialist, but will retain the technical integrity of our main articles.

The editorial team for the popular material will be Paul Garner, Eoghan Mhor and Neil Brownrigg. The technical material will be edited by David Tyler, Nancy Darrall and Peter Senior. To maintain continuity for the time being, John Peet will continue to coordinate the production with Jim Balmer who has been our Graphics Artist for several years.

I would like to take this opportunity to thank not only Jim but also my co-editors, Paul Garner and Peter Senior. This journal has been prepared by amateurs with very busy lives. Jim's professional guidance has been much respected and has been very beneficial. We have also been blessed with a number of volunteers who are now helping in checking manuscripts and producing artwork. I believe their input is going to enhance the quality of the journal in the future.

On the scientific front, the big topic of the next few years is going to be the continuing publication of the human genome's detail. The detail published so far is exciting and we all await with interest the full information. Of course, it will carry risks. There will be a lot of moral debate about what to do with this new knowledge. No doubt we will cover these issues as they arise in our regular mailings.

Following the publication of the composition of the human chromosome number 22, it was reported that the genes are contained on only three per cent of the chromosome's code. However, we must be cautious of preliminary reports as time often changes the initial conclusions.

At the beginning of the last century, we were told that there were around a hundred or more vestigial organs, the left-overs from evolutionary history. That number has dramatically reduced as medical research has shown time and time again that these organs are not vestigial at all. When I was asked a few years ago about 'junk DNA', I forecast that history would be repeated and we would see that the genetic information then described as 'junk' would be found to be vital. We must not confuse our ignorance with lack of function.

To the creationist, the recent and repeated discoveries of purpose in the previously unidentified DNA is not surprising, but according to prediction. We are grateful to Dr. Nancy Darrall for her work in bringing us up to date on this topic in this issue. One writer commented on the analogy between the 'junk DNA' and computer disk drives. The 'junk' sometimes serves as spacers in the same way as formatting spaces on the disk drive. As the code is transferred to the RNA, the spacers are removed. This is a precision process indicating effective design. As far as I know, no-one has suggested that computer hard disks and their formatting procedures arose by accident!

After Dr. Darrall completed her article, further developments were reported. In one, a correspondent reported that 'If it weren't for "junk DNA", women would be in trouble' (Jonathan Knight, New Scientist, 2000, (17 June):21; E. Eichler *et al.*, Proceedings of the National Academy of Sciences, 2000, 97(12):6634-6639). Apparently one of the X chromosomes is 'silenced' by the LINE-1 elements referred to by Nancy. If this did not happen, 'females would get a lethal dose' of the X chromosome.

It is not only important for us to understand our science correctly, but we must continually ask if we are reading the Scriptures correctly or imposing on them concepts that are not there. In the continuing discussions about the geology of the earth and how that relates to biblical history, questions have been raised about the meaning of various passages. In order to further this debate, we have included another article by Steven Robinson in which he has carefully reviewed some of the key words in Scripture.

These two articles are, of course, technical and require careful reading, but we believe that they are valuable contributions to the creation–evolution debate.

J.H.J.P.

Junk DNA—More Vestigial Organs?

Nancy M. Darrall

THE HUMAN genome project is well under way. It is predicted that by 2005 every one of the estimated 45,000–100,000 human genes will have been identified. You might be forgiven for thinking that we will then have everything needed to understand the codes that determine our make-up, the genome. The reality is very different. It would be like saying that you understand the plot of 'Twelfth Night' if you can merely list the characters in the play and have no grasp of how the plot unfolds through the chapters, the way the individuals interact and the challenges and implications of the book.

Genes, which contain the genetic code for proteins and RNAs are strong evidence for a Creator. All language contains coded information and can only be generated by a thinking being. The DNA code is universal, which is contrary to the predictions of evolutionary theory; this code should have diversified by mutation and natural selection along with the diversification of the forms of life. Any sequence of DNA without a known function at the moment does not in any way detract from these origin of life issues. There is clear evidence for a Creator from the design of living things, coded in DNA. From a model of biblical creation we would expect the DNA code as originally created to be functional, either at that time or providing in-built variation for the future. However, it is likely that the original designs are now degraded by changes to the genotype as a consequence of the fall, the most obvious example being heritable diseases.

Only 3–5% of the human genome consists of strings of triplets that code either for the amino acids to make up our proteins or for the RNA that is involved in the transcription of the code from the DNA (Dunham *et al.*, 1999). At first the rest was dubbed *'selfish DNA'* or junk DNA, because it appeared to have no function.

Some repetitive sequences of DNA seemed to increase in copy number at the host's expense; said to be a *molecular parasite* of no consequence to the cell or the species as a whole. Some view junk DNA as *a relic from past evolutionary changes*, fossilised DNA of neither positive nor negative selective advantage and carried by the genome because there is no known mechanism to remove it. Creation, they argue, is disproved because *God would not have designed something that was of no use.* Similar arguments for evolution claiming that vestigial organs were the remains of past functional parts of animals are disappearing from textbooks now that the majority of the 100 or so quoted about 100 years ago are known to be an integral part of the body's design.

So does junk DNA have any use? Where does it fit into a creationist model? The complex roles of a variety of different types of 'junk' have been unfolding rapidly over the past 15 years. The subject is moving fast and our understanding is continually changing and developing as more information comes in. Structural roles for telomeres, centromeres and satellite DNA are well known. Regulatory roles, including a role in developmental changes, are known for introns, retroposons, untranslated regions and satellite DNA. Because many types of DNA previously thought of as junk DNA are now known to have a role, the name non-coding DNA will be used for all types of DNA that does not code for proteins or RNA. This article discusses some examples and there are hundreds of others in the scientific press. We can no longer consider genes as beads on a string, but as a complex three-dimensional organelle, a unified entity of interdependent components (Bernardi, 1989, von Sternberg, 1992). Long range interactions among DNA segments, both inter- and intra-chromosomal, influence the genetic activity of each region (Manuelidis, 1990). DNA is irreducibly complex.

Alongside the interest in identifying human genes many have used the opportunity to compare genomes of other species and build evolutionary family trees on the basis of differences in coding sequences of certain types of non-coding DNA. This has already been done with mitochondrial DNA, cytochrome C and various cell constituents. Evolutionists would argue that changes in the coding sequence, mutations, are copied down the generations and leave us a record of the past. Creationists may view the differences as variations in the original design or corruption of that design at some time after the biblical Fall. One way to distinguish between copying and independent creation is suggested by analogy to a case in USA legal history. The author of a textbook claimed that another author had plagiarised his text, the defendant maintained that the two books would be similar because the subject matter was the same. Errors in the original text were duplicated in the second and the courts ruled that it was inconceivable that identical errors should be made by the two authors. *So, if the same functionless DNA is found in different species at the same place, then does this provide evidence of evolution?* Surely the probability of the same mutations occurring at the same position in another plant or animal must be inconceivable as in the case of the plagiarised textbook (Max, 2000).

Patterns point to more than a random assortment of molecules

Hints that something interesting is lurking in non-coding DNA have come from mathematics and linguistics. Statistical patterns are present; the meanings of these patterns are

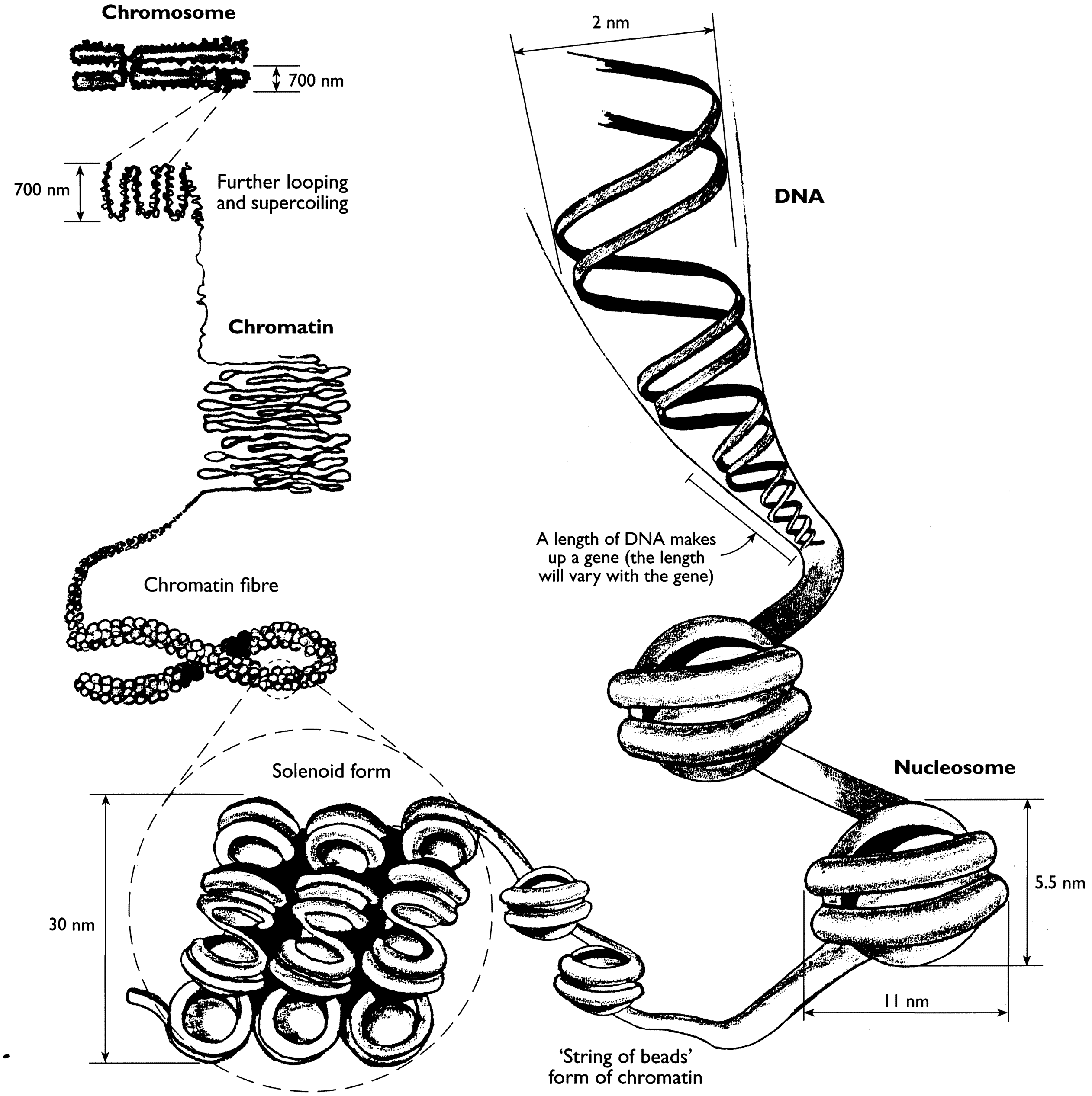
Chromosome
700 nm
700 nm
Further looping and supercoiling
Chromatin
Chromatin fibre
Solenoid form
30 nm
2 nm
DNA
A length of DNA makes up a gene (the length will vary with the gene)
Nucleosome
5.5 nm
11 nm
'String of beads' form of chromatin

Fig. 1: The structure of chromosomes

unclear, but they are consistent and the DNA from each class of organisms appears to have its own statistical signature (Amato, 1992). Statistical patterns that occur in natural languages are also found in non-coding DNA (Mantegna *et al.*, 1994) suggesting that non-coding DNA carries information.

An introduction to the main types of DNA

DNA sequences that occur once only (single copy DNA) or sequences repeated just a few times (low copy number DNA), make up 60% of our genome. A typical example would be genes for α globin which occur in one to three copies and human β like globins where there are four main types, all related to each other but used for different purposes. This type of DNA includes what we popularly think of as genes, the protein and RNA coding sequences (3–5% of the total), also introns and the spacer DNA that separate genes. Only 25–50% of genes occur as single copies, the remainder occur as gene families. These are similar, but not identical genes that some think may have arisen by a process of gene duplication and accumulation of mutations. Some members of a gene family are dispersed through the genome and some are clustered at one location. When there are multiple copies, mutations that make one or more of a gene copy non-functional can be tolerated, as long as a functional copy remains. Non-functional copies are known as pseudogenes. Some consider them as decaying relics of genes that were once functional. The α globin gene cluster in the rabbit contains two pseudogenes, however, there is evidence that these may be functional (Hardison *et al.*, 1991).

Repeated sequences of higher copy number (intermediate repeats) include a small number of sequence families; each member of a family consists of similar but not identical sequences. Most are mobile genetic elements (transposable elements) and this type of DNA occupies as much as one third of the genome (Smit *et al.*, 1995). Highly repetitive DNA consists of short sequences repeated up to a million times in the genome. This is satellite DNA and accounts for about 10% of the total DNA (Sudbery, 1998).

Junk DNA comes in a number of clearly recognisable types

Some non-coding DNA already has well-understood functions. Telomeres are found at the ends of chromosomes and protect them from 'fraying' or sticking to other chromosomes. (See figure 1 to understand the relationship between DNA, genes and chromosomes.) The identical halves of the chromosomes are called chromatids. Centromeres attach the two chromatids together and are vital for the movement and pairing of chromosomes during cell division. Both contain tandemly repeated sequences. (These are repeated sequences of bases that are identical when read in the same direction, as compared to inverted repeats that are mirror images when reading in the same direction.) Replacement of a functional centromere with one consisting of a random assortment of bases leads to loss of function (*e.g. Schizosaccharomyces sp.*, Clarke and Baum, 1990). Sequences are not the same in related species or even in other strains of the same species. This means that although there is no need for the bases to be present in the same order as in protein-coding DNA, there is a requirement for a certain pattern of molecules; presumably the functional centromere has to be a particular shape.

1. *Introns* are 'interruptions' in sequences of DNA within protein-coding genes, sometimes the protein coding portion (the exon) forms only small patches in long stretches of introns. When the messenger RNA is formed as the first step in protein synthesis (see figure 2), the introns are snipped out of the RNA sequence by enzymes which then 'stitch' the broken ends together. Some introns can cut themselves out and move around the genome. Some introns code for so called sno RNA molecules which accumulate in the nucleolus (named *sno* because they are *s*mall and are found in the *n*ucle*o*lus, the part of the nucleus responsible for making ribosomes) and are thought to play a role in ribosome assembly there. (Ribosomes are involved in the manufacture of proteins; see figure 3). There are examples of genes where the introns appear to be the 'useful' part, whilst the remainder that would normally code for a polypeptide appears to have no function and is rapidly lost from the cell. One example, a gene called UGH, contains an intron U22 which codes for 8 separate sno RNA molecules. This arrangement permits the eight molecules to be present in equal quantities at the same time, because the DNA that codes for them is read off as a single unit. The role for the remainder is to hold them all together (Moore, 1996; Tycowski *et al.*, 1996). Introns also play an important role in the control of gene expression. They can control the recognition and transcription of the protein-coding portion (Sterner *et al.*, 1996). Hundreds of examples of introns *enhancing and inhibiting the transcription of genes* are known (see http://www.jps.net/bygrace/evolution/junkdna. html). They can act as primary regulatory elements, prevent excessive gene transcription, interact with other promoters and play a role in the developmental changes that occur during growth to maturity (a few examples are given in Box 1).

(1) *Prevent gene transcription* until removed by a nuclear enzyme in tRNA genes (Abelson, 1992).
(2) *Prevent excessive transcription* into the coding region of the gene when viral insertion occurs in the human c-Ha-ras gene (Lowndes *et al.*, 1990).
(3) Related enhancers in the intron of the β1 tubulin gene in the fruit fly *control gene expression in certain tissues* and at certain stages of development (Kohler *et al.*, 1996).
(4) Act as an *enhancer* for transcription of the α globulin gene in mice and humans (Bouhassira *et al.*, 1997).
(5) An intron forms *an enhancer complex which acts synergistically with the promoter* downstream to give a complex control system for the development of the reproductive tract in the fruit fly. This activates a gene coding for the enzyme glucose dehydrogenase (Gld) during metamorphosis and in the mature fly (Keplinger *et al.*, 1996).
(6) The third intron in sequence in the orthodenticle gene (otd) is the *primary regulatory element* in photoreceptor cells of the fruit fly, *Drosophila*, controlling the timing of gene expression. The eyes start to develop at a specific larval stage and acquire the final adult form during pupation. If a mutation damages this intron, the photoreceptor cells become disorganised and appear to be pushing the cones out of alignment (Vandendries *et al.*, 1996).
(7) *Negative regulatory element* in an intron of Ng-CAM gene in chicken. It regulates the expression of cell adhesion molecules important during the development of the nervous system (Kallunki *et al.*, 1995).

Box 1: Role of introns

2. Untranslated regions adjacent to transcribed genes

Some genes have regions at either end of the translated DNA code that are untranslated (UTR) and so could be construed as junk. In coxsackie B viruses (here RNA, not DNA codes for the genes), this region plays a role in the 3-dimensional structure of the gene which is essential before viral replication can occur. The RNA must be a particular shape to bind proteins involved in the initiation of the RNA synthesis required (Melchers *et al.*, 1997). Untranslated regions at either end of a gene can control expression of genes by regulating translation, storing messenger RNAs in an inactive state until the right stage of development is reached (Ranganathan *et al.*, 1997) or restricting translation to one of two subunits needed for a protein to be functional. In α and β human globin genes, untranslated regions are involved in maintaining the stability of mRNA molecules so that they can function for several days. In red blood cells this means that mRNA can accumulate to higher levels and produce more of the building blocks of haemoglobin. Mutation of this region causes thalassæmia, a form of anaemia particularly prevalent in the Mediterranean basin (Russell and Liebhaber, 1996). Another example are maternal mRNAs in human oocytes, which are kept dormant until late oogenesis or early embryogenesis when their translation is activated (Seydoux,

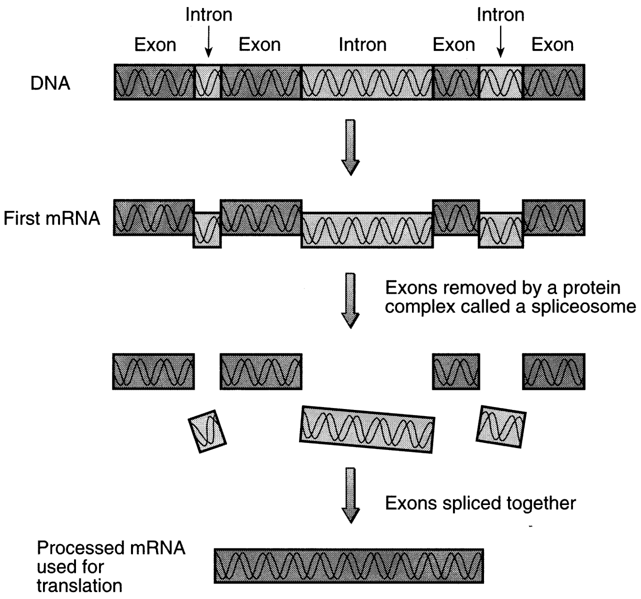
Intron
Intron
Exon
Exon
Intron
Exon
Exon
DNA
First mRNA
Exons removed by a protein complex called a spliceosome
Exons spliced together
Processed mRNA used for translation

Fig. 2: Exons, introns and intron splicing in a gene

1996). Many other examples of roles for this type of DNA sequence are given in Wood *et al.*, (1996).

3. Junk DNA that moves around the chromosomes, transposable and repetitive sequences

These repeated DNA sequences are copied and the copy is thought to move around the genome. Spread and maintenance of most elements probably occurs by transfer from parent to offspring through the germline (see figure 4). Examples are satellite DNA, retroposons *e.g.* LINEs, (*l*ong *i*nterspersed *n*uclear *e*lements *e.g.* L1 and SINEs, Alu and pseudogenes; see Box 2).

Transposable elements occur extensively in the human genome in non-coding regions and within introns. These elements can affect the phenotype. Insertions cause a substantial proportion of known mutations with major effects. They may also contribute to quantitative variations in traits (Berg and Howe, 1989; Mackay *et al.*, 1982) and may regulate the expression of nearby genes. Mutations can occur at the original site of the transposon when repair of the broken ends causes changes in the DNA sequence of the strand. Mutations also occur at the site of insertion in a gene. When the number of bases inserted is other than three, a shift in the reading frame occurs downstream so scrambling the DNA coding (figure 5). After inserting themselves into a new site they can multiply, further affecting the genome.

The appearance and disappearance of transposable and interspersed repetitive elements may be controlled directly by the cell, as there can be dramatic changes in the numbers, types and distribution over even a few generations (von Sternberg, 1992).

What then, are the results of these transpositions? A significant number of genes include Alu in one of the end regions and a number of regulatory roles for Alu are known. These include the restriction of transcription to specific tissue types and regulation of activity by response to other cell constituents (Britten, 1996; Mighell *et al.* 1997; see Box 3). Alu may affect the function of other genes by binding protein or RNA molecules to the gene, or by the Alu itself competing for essential transcription and/or DNA replication factors. Similarly, there are examples of autonomous transposable elements eg LINEs, SINEs and retroviruses with regulatory roles in cell metabolism.

Some transposable elements cause diseases, these are the ultimate in selfish genes. Those few L1 elements (see Box 2) in humans that are full length and are actively transposing have the ability to cause mutation, disease, genetic variation and polymorphism. Other, less complete L1 sequences can be responsible for disease when they insert at certain sites within genes, *e.g.* haemophilia A in factor VIII gene (Kazazian *et al.*, 1988). One of the Human Endogenous RetroVirus-like sequences (HERVs), HERV-K, contains members that encode functional enzymatic proteins, viral

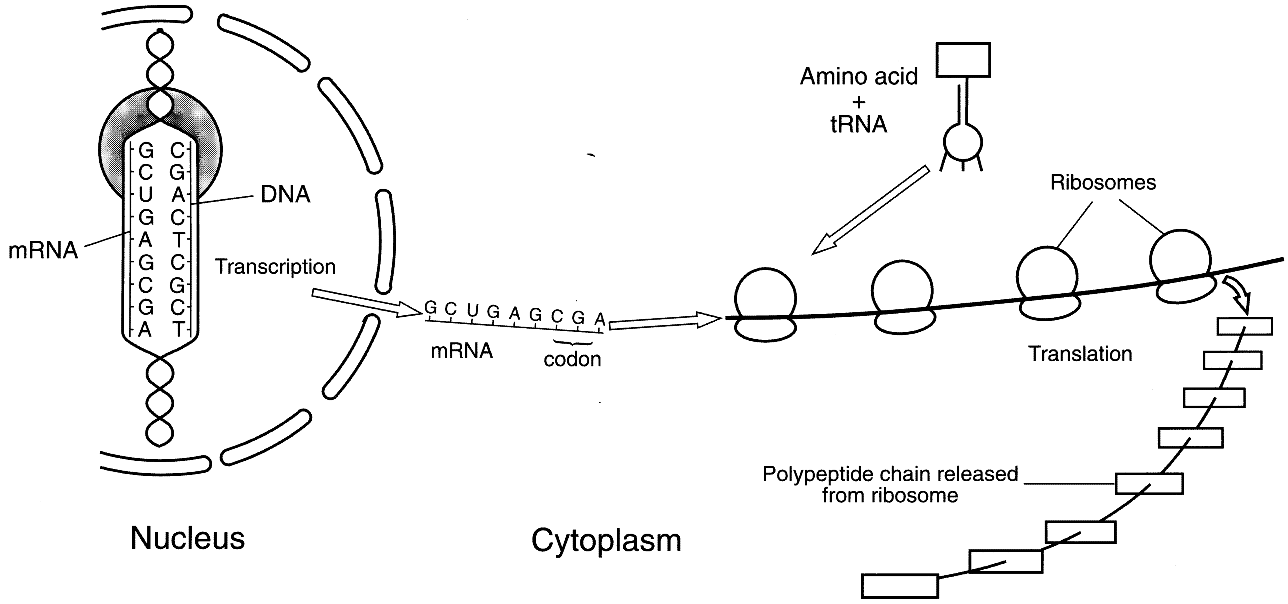

Figure 3: Simplified diagram of protein synthesis in the cell

particles and auto-immune antigens which shows that they have retained some of the retroviral function. Conrad *et al.* (1997) suggests that these sequences cause insulin dependent diabetes in some cases.

Movement of transposable elements in non-germline cells occur in human cancers, where cells divide rapidly, for example in leukaemias, lymphomas and also solid tumours. Alu sequences are involved in a variety of human inherited disorders for example neurofibromatosis, Huntington's disease and several metabolic disorders (Heikkinen *et al.*, 1997; Kazazian, 1998, Kornreich *et al.*, 1990 and references therein). In the fruit fly, insertion of transposable elements can cause over-expression of a gene, interference with a gene promoter, premature cessation of transcription and complex interactions in the genome (see Box 4).

4. *Multigene families*

Some genes have two or more similar or identical copies. This may seem unnecessary, even junk, but it allows flexibility in expression between various tissues and at different developmental times (Dover and Flavell, 1982; Baltscheffsky *et al.*, 1986; Markert, 1987).

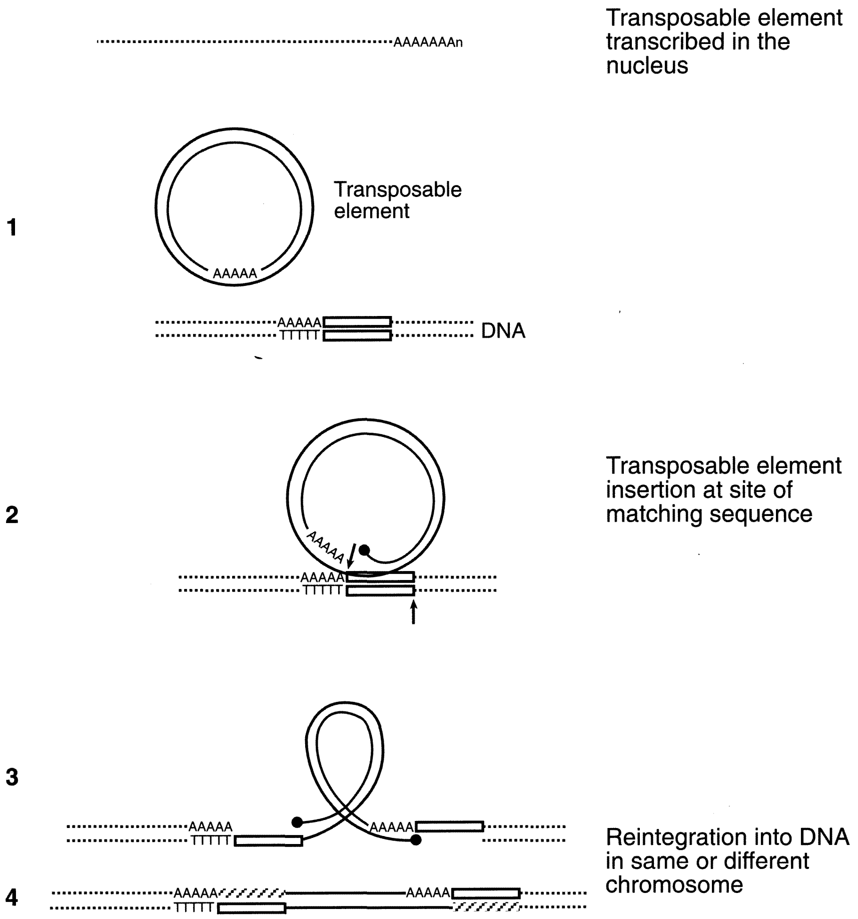
AAAAAAAn
Transposable element transcribed in the nucleus
1
Transposable element
AAAAA
AAAAA
TTTTT
DNA
2
Transposable element insertion at site of matching sequence
AAAA
AAAAA
TTTTT
3
AAAAA
TTTTT
AAAAA
Reintegration into DNA in same or different chromosome
4
AAAAA
TTTTT
AAAAA

Figure 4: Movement of transposable elements in the genome

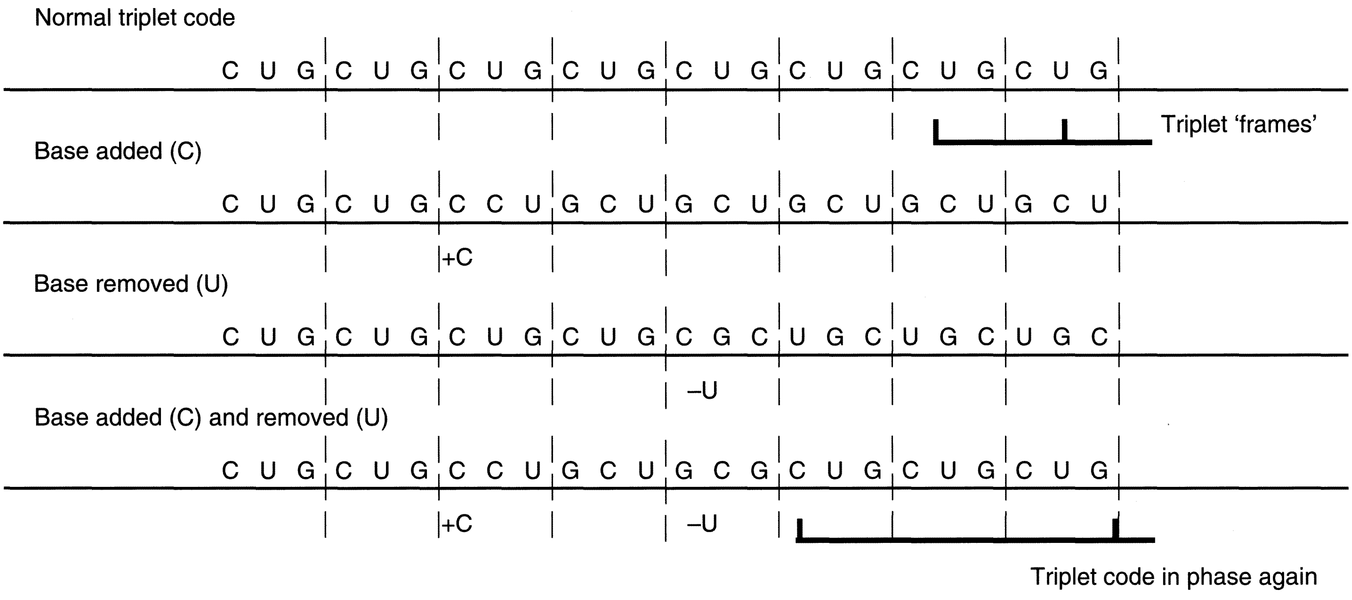
Normal triplet code
C U G C U G C U G C U G C U G C U G C U G C U G
Triplet 'frames'
Base added (C)
C U G C U G C C U G C U G C U G C U G C U G C U
+C
Base removed (U)
C U G C U G C U G C U G C G C U G C U G C U G C
–U
Base added (C) and removed (U)
C U G C U G C C U G C U G C G C U G C U G C U G
+C
–U
Triplet code in phase again

Figure 5: Diagram to show the effect of changing the reading frame in DNA

(1) Transpose directly through DNA copies by a 'cut and paste' process.
(2) Transpose via an RNA copy of the element, by reinsertion of the product of reverse transcription (DNA RNA DNA).
(2·1) autonomous—encode the protein required for their own reverse transcription.
  (2·1·1) Autonomous transposable elements with long terminal repeats, *e.g.* copia and gypsy in the fruit fly, *Arabidopsis* Ta1, yeast Ty elements and HERVs, the human endogenous retroviruses. They lack the functional env gene that codes for the envelope protein of an infectious virus particle.
  (2·1·2) Lack long terminal repeats, LINEs *e.g.* L1, a major family of TE in mammals with 50,000 copies in the human genome. Most LINEs are truncated at one end, some 3–4,000 are full length in humans, 5 subfamilies are known to be active in humans today.
  (2·1·3) Retroviruses (1–2% of human genome), which have infectious capabilities in addition to a requirement for insertion into the host gene as part of their life cycle. Well known examples are the mammalian leukaemia virus and the mammalian immunodeficiency viruses e.g. HIV/AIDS.
  (2·1·4) There are also retrovirus-like elements which have a range of affinity to retroviruses. Some are clearly related and others do not have similar DNA sequences, but share retroviral characteristics such as long terminal repeats and tRNA binding sites.
(2·2) non-autonomous and lack the transposase activity. This group include SINEs, short *i*nterspersed *n*uclear elements and pseudogenes. The most common SINE in humans has been called Alu, with about a million copies, 5–10% of the total DNA content. These are the most highly repeated elements in all mammalian genomes, with tens to hundreds of thousands of copies. They are similar to small untranslated RNAs such as 7SL RNA or tRNA genes and are thought to have been formed from them. They lack coding capacity, but include an internal RNA polymerase promoter and an A-rich end. Transcription back into DNA takes place in the presence of a reverse transcriptase enzyme, such as the enzyme of this type included in L1. The SINE is really 'plundering' the enzyme from L1 (Charlesworth *et al.*, 1994; Kazazian, 1998; Kidwell and Lisch, 1998; Smit, 1996 and Wichman *et al.*, 1992).

Box 2: Types of transposable elements

It also provides versatility so that there is potential for phenotypic diversity without the creation of new genes. Alternatively, identical genes allow production of large amounts of the same compound. Similarly, there are supergene families in which one or more sections (each of which produce a functional unit of protein) are the same (Li, 1985).

5. Pseudogenes

These are genes which are unable to form protein or RNA because of one or more changes in the sequence of bases. They fall into the same group of transposable elements as SINEs because they reinsert into the DNA via an RNA intermediate. However, unlike SINEs, pseudogenes are unable to move autonomously. It is estimated that there is a total of roughly 15,000 pseudogenes (0·6% genome) in humans compared to 45,000–100,000 functional genes (Dunham *et al.*, 1999). In the olfactory gene family sequence (Rouquier *et al.*, 1998), 72% of the sequence consists of pseudogenes in humans.

The unitary pseudogene is a rare type of pseudogene and occurs in the place of a functional copy. One example is the GLO gene family in primates and humans (Ohta and Nishikimi, 1999), which is unable to code for an enzyme needed to manufacture vitamin C. In other mammalian species, the gene is functional. Evolutionists argue that as such a large gene defect is rare, it must have occurred first in our primate ancestors and the pattern of occurrence in mammals can be explained by evolutionary descent. However, Max (2000) accepts that a separate mutation would be necessary to account for the pseudogene in guinea pigs which belong to another branch of the mammals. Other examples of unitary pseudogenes can be found in the recent literature.

Classical duplicated pseudogenes occur much more frequently and appear to arise following duplication of genes that gives two or more repeats side-by-side. One gene remains functional, and one or more mutations occur in the other(s). The mutant gene may also be active with a modified function or it may be functionless and then it is called a classical duplicated pseudogene (Max, 2000). One example is the twelve member β globin gene locus in goat; three members are pseudogenes (Shapiro and Moshirfar, 1989). Another example is the gene encoding an adrenal enzyme that varies in copy number in humans. It is normally present as a single copy in both normal and deficient individuals and occurs together with its pseudogene which is present nearby. The authors conclude that these rare mutations can be expected to arise independently in unrelated individuals (Wedell and Luthman, 1993). Both α and β clusters of haemoglobin genes in humans include pseudogenes of this type (Chang and Slightom, 1984). Disease can occur where both genes are active following duplication, for example partial gene duplication in cancerous cells, extra copies of genes in William's syndrome and α thalassæmia gene (Mazzarella and Schlessinger, 1998).

Processed pseudogenes are thought to arise from RNA copies of protein-coding genes after the introns have been removed and the poly (A) tail which is characteristic of RNA transcripts has been added (figure 6). Processed pseudogenes are usually non-functional because of the regions that are missing, including the reading frame and regulatory sequences (compare with structure of retroposons discussed above). The RNA copy of the gene is reverse transcribed into DNA and inserted elsewhere than the original gene. The copy may insert into another chromosome and there are examples of placement in the introns of other genes as well as in dense clusters adjacent to the centromere (Dunham *et al.*, 1999 described 134 on human chromosome 22).

Like classical pseudogenes, processed pseudogenes appear to accumulate mutations without detriment to the host. Most contain multiple mutations including stop codons, insertions and deletions that cause changes in the reading frame and therefore premature termination of translation. This means that they cannot encode a full length functional polypeptide.

Pseudogenes cannot reinsert themselves, but either retroviruses or autonomous transposable elements such as

(1) Alu inhibits cell growth (Sakamoto *et al.*, 1991).
(2) Alu sequences in the last intron of the CD8 gene in humans contain binding sites to regulate *transcription.*
(3) Alu *controls transcription in certain* specific *tissue types* including basophils, some T cells and of one chain of the high affinity IgE receptor protein.
(4) Alu confers *sensitivity to calcium ions* in human parathyroid hormone.
(5) Alu acts as a *transcriptional enhancer* in a breast cancer gene in the presence of oestrogen.
(6) Alu acts as a *silencer* for the Wilms tumour I gene that is active in certain tissues and developmental stages in man.
(7) Alu upstream of the human ε globin gene down-regulates transcription by a factor of 20 to 30 fold, probably by *interfering with transcription* of the gene (Wu *et al.*, 1990).
(8) LINEs have a role in suppressing transcription of an insulin gene in rats that is dependent on an enhancer (Laimins *et al.*, 1986). The chromatin structure is probably altered to *limit access to transcriptionally active molecules.*
(9) A retroviral element, NICER in gene d4 can be both *induced and inhibited* in rats. Transcription occurs after the addition of a nerve growth factor and is inhibited by cAMP molecules (Cho *et al.*, 1990).
(10) Transposable elements *gypsy* and *copia* in the fruit fly can reverse sterility in females. These elements are known to contain a variety of regulatory signals within their long terminal repeats which can affect the expression of nearby genes (Mével-Ninio *et al.*, 1989). When inserted near other genes, both lower and higher levels of gene transcription have been found.
(11) The effect of a transposable element insertion can be suppressed or enhance by a mutation at a second site, for example the retrotransposon, gypsy, which binds the protein coded for in the gene 'suppressor of hairy wing', Su(Hw), to give its effect. If there is a mutation at Su(Hw), then the effect of gypsy is reduced, or absent, showing a clear interaction between these two sites (Spana *et al.*, 1988; Corces and Geyer, 1991).

Box 3: Interaction between transposable elements and genes (discussed in Britten, 1996 and Mighell et al.*, 1997 unless otherwise stated)*

LINE 1 may be responsible for this (Smit, 1996). Normal human cells possess this ability (Maestre *et al.*, 1995) and so, at least in some cases, retroviruses are not necessary for pseudogene formation. No insertions of processed pseudogenes have been seen in modern times in humans or mice (Tchénio *et al.*, 1993).

Are pseudogenes totally functionless, the classic selfish DNA? There are examples of pseudogenes that are very similar between species. This is usually a sign that the sequence has function (Bernardi, 1989). Functionless DNA can be readily removed, this has been observed in cryptomonads (Beaton and Cavalier-Smith, 1999) and in *Drosophila*, (Petrov *et al.*, 1998), although the mechanism for deletion is not known. It is therefore reasonable to suggest that some apparently functionless pseudogenes do in fact have a role in the genome. The presence of an unmethylated sequence of dinucleotides known as CpG islands, normally associated with functional genes, suggest two pseudogenes in α-like globin gene clusters of rabbit are active (Hardison *et al.*, 1991). In Max (2000), the argument is made that as pseudogenes have no function, the presence of the same pseudogene in different species, *e.g.* man and chimpanzee (Kawamura and Ueda, 1992) indicates a common evolutionary ancestor, rather than being part of the originally created design, as functionless sequences would not have been part of any original design. However, some pseudogenes do have a function and this possibility needs to be considered for each new case. It is important to find out if these pseudogenes occur with CpG islands, if so, they are likely to be functional and so a feature of the design of the two species. There are examples of the effects of pseudogenes in Box 5. Here we see some pseudogenes with definite roles, some apparently have no clear role and others cause diseases. The use of processed pseudogenes in supporting evolutionary theory is considered again later in this article.

Interestingly, comparison of the fœtal gene in the β globin gene clusters in humans, gorilla and chimpanzee show that they contain the same number of genes including three pseudogenes (Chang and Slightom, 1984). The genes contain the same transcriptional and translational differences when compared with the functional genes, which suggests that they have a role in their present form, possibly as regulators. There is a high degree of sequence correspondence, the number of differences between them being only one third of that normally predicted for sites evolving at a neutral rate (of no selective advantage).

6. Satellite DNA, the same thing over and over again—is it junk?

Satellites are short sections of non-coding DNA repeated hundreds or thousands of times at a stretch, each identified by the repeated pattern of bases. They are something with which we are all familiar, although probably without knowing them by name. Genetic fingerprinting analyses the lengths of the minisatellites of an individual and the more that are analysed, the more unique the pattern for identification. They are probably the products of unequal cross-overs or past retroposon insertion (Nadir *et al.*, 1996). There are examples of the effects of satellite DNA in Box 6.

Highly repetitive DNA or satellite DNA is essential to the function of centromeres and occurs in telomeres as well as

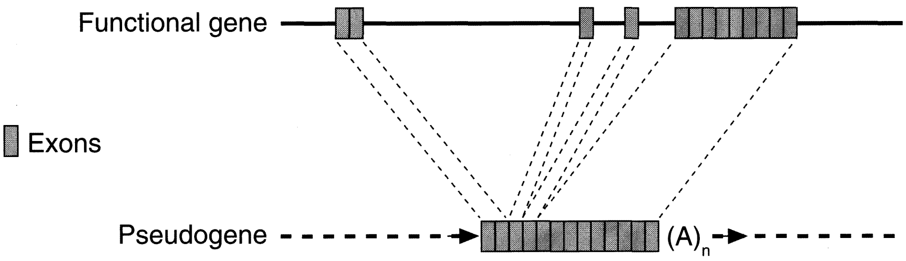

Figure 6: Schematic diagram of processed pseudogene formation

(1) The *tom* transposable element inserted into the gene *Om(ID)* leads to over-expression in eye tissues causing defects (Tanda and Corces, 1991).
(2) Insertion of a copia-like transposable element upstream caused reduction in transcription of the gene for alcohol dehydrogenase in the tissues and life stages where it is normally expressed (Strand and McDonald, 1989). This occurred *by interference with gene promoters*; one is utilised in the larval life stage and another in the adult.
(3) Insertion of copia at the white locus, causes *premature termination of transcription* in the long terminal repeat of copia (Bingham *et al.*, 1981).
(4) A *complex interaction* occurs in the adh gene when a retroviral-like element is inserted at a particular site in the genome (Strand and McDonald, 1989). Insertion reduces the activity of the gene in certain types of tissues and stages of development in the adult fly. It appears that copia expression is under the regulation of at least the two gene loci, su(f) and su(wa). The authors suggest that this may play a role in the development of new regulatory and developmental networks.

Box 4: Effects of transposable elements in the fruit fly

in the human sex chromosome, the Y chromosome. Shorter repeats are called minisatellites and microsatellites (Elder and Turner, 1995). Minisatellites have only a small number of these tandem repeats and there is a great deal of variation between individuals in the number of repeats inherited (Charlesworth *et al.*, 1994; Dunham *et al.*, 1999). Comparisons showed that these variations have no effect on the plant or animal and so they are assumed to have no function. However, this does not rule out important structural and organisational roles, including that of chromosome pairing and cross-overs between chromosomes. Some satellite families are simple repeats, for example of AT or AG units and these occur in introns and also between genes. Some regulate gene expression in a way that allows different genes to be switched on and off during different stages of an organism's development (Wu *et al.*, 1990).

A third type of microsatellite is the (CRG)n family, a simple trinucleotide repeat (not to be confused with classical pseudogenes, where a whole gene has been replicated). In contrast to the previous two types, these are located within or close to coding sequences. They are involved in human heritable diseases such as fragile X, myotonic dystrophy and Huntington's Chorea, when 'runaway' multiplication of the sequences occurs (Sutherland and Richard, 1995). Replication and insertion of non-coding DNA by random processes in an evolutionary model is clearly not a neutral event, but often harmful to the organisms concerned.

Junk DNA, the library shelves—a structural role

It has been shown that there is a whole range of different patterns of the variety of non-coding DNA which occur between similar species and even between gene pools and within gene pools of the same species. In these cases, it is unlikely that the individual DNA molecules themselves are the key to any genetic role. However, non-coding DNA in the nucleus does have a structural role as the skeleton to allow the genes to function. The amount of the DNA and the way that it folds directly determines nuclear volume. Large cells have large nuclei and this can be explained by a greater proportion of non-coding DNA, as the copy number of protein-coding genes does not need to be greater in larger cells. The increased total mass of DNA can accommodate more ribosomal and messenger RNA and also molecules related to their synthesis and storage. All of these need to move around the nucleus and greater access will allow the cell to grow to a larger size (Beaton and Cavalier-Smith, 1999 and references therein and Cavalier-Smith 1985, 1991).

Particular sequences of non-coding DNA may have a role in compartmentalisation within the nucleus for orderly transcription and replication within highly folded chromosome domains (Manuelidis, 1990). Hennig *et al.*, (1989) reached similar conclusions for the Y chromosome of the male line in *Drosophila hydei*. This chromosome has very few protein-coding genes, but it includes short tandemly-repeated DNA sequence clusters interrupted by more variable sections. Portions of the chromosomes take on the shape of giant lampbrush loops and RNA is transcribed from long sections. Specific nuclear proteins become associated with this RNA, dividing the nucleus into compartments which are essential for normal development of sperm formation.

Another type of non-coding DNA with a structural function is the palindrome; here one half of a section is a mirror image of the other. These occur on several human chromosomes in areas associated with crossing-over during gamete formation and are important in fold-back structures of DNA (Mirkin *et al.*, 1987).

Junk DNA, not just the library shelves, it controls use of the copier!

The specific three dimensional structure of the chromatin in the chromosome may also be the basis for other potential coding functions. Examples are a gene expression code which regulates transcription, a replication code which controls the timing of this process during the cell cycle and a recombination code which controls the active recombination of tandem repeat sequences (von Sternberg

(1) Becomes a functional gene by acquiring a promoter (see Kleene *et al.*, 1998).
(2) Functions as a pre-immune repertoire where one gene provides material for somatic gene conversion of another to give antibody diversity in rabbit (Becker and Knight, 1990).
(3) Donates sequences for gene conversion to provide antibody diversity in chicken (Reynaud *et al.*, 1987; Thompson and Neiman, 1987).
(4) Becomes a functional gene by correction in the germ line (Trabesinger-Ruef *et al.*, 1996).
(5) Captures exons and introns of unrelated genes to make a functional gene (Long and Langley, 1993).
(6) Induces mutations in a nearby functional gene, e.g. causing Gaucher disease (Eyal *et al.*, 1990).
(7) Transfer of information between two pseudogenes (Shapiro and Moshirfar, 1989).

Box 5: Effects of pseudogenes

(1) Adenine rich sequences act as navigators for transposon insertion by matching of adenine-rich sequences, so preserving and amplifying them (Conrad *et al.*, 1997).
(2) One minisatellite family (DeLange *et al.*, 1983) is a promoter for expression of cell-surface glycoproteins in trypanosomes (a genus of flagellate unicellular animals, including the one responsible for sleeping sickness). These glycoproteins provide the protective surface coat for the parasite. Changes in the protein coat occur by duplicative transposition in the gene to give arrays of mini-exon repeats which function as a repetitive promoter for efficient transcription.
(3) Simple repetitive sequences are present in the MHC-DRB genes which are a major group of genes responsible for histocompatibility (Maueler *et al.*, 1992). These sequences bind nuclear proteins and exhibit characteristics of a specific DNA-protein interaction, but the function of these processes is not yet known.
(4) The family of (GC)n repeats occur at low numbers and occur largely up and down stream of both 'housekeeping' genes and many of those genes expressed only in specific tissues (Gardinger-Garden and Frommer, 1987). They are generally linked with active gene expression.
(5) Satellite DNA allows suppression of clinically observable gene abnormalities which were a result of replication of a band of protein-coding DNA in a region of human chromosome 9 (Macera *et al.*, 1994).
(6) A simple repetitive sequence upstream of the ε globin gene appears to down-regulate the expression of this gene after the first 10 weeks of embryonic development in humans. It probably interferes with transcription of the gene (Wu *et al.*, 1990).
(7) Satellite DNA provides compartmentalisation for chromatin. This changes during tissue development of neurons (Holowacz and DeBoni, 1991) and plays a role in cell differentiation and changes in physiological state by affecting the transcriptional state (on/off) of the chromatin.
(8) The long terminal repeat portions of the retroposons imposed a gonadotrophin requirement on the activity of adjacent genes in endocrine tissues that synthesise steroid hormones in response to pituitary hormones (Schiff *et al.*, 1991).
(9) Simple trinucleotide repeats within or close to coding sequences are involved in human heritable diseases, fragile X, myotonic dystrophy and Huntington's Chorea.

Box 6: Effects of satellite DNA

et al., 1992; Trifanov, 1989). The functions of a variety of non-coding DNA sequences in regulating gene expression have already been discussed. These include roles for introns, satellite DNA, untranslated regions adjacent to the gene itself and also transposons which include enhancer or promoter elements able to influence the behaviour of nearby host genes. Certainly, the interplay between enhancer and silencer elements is part of an elaborate mechanism for determining the level of gene activity in cells, between different tissue types and the various developmental stages of an organism.

Junk DNA—role in the genetic variation of a population

It is likely that changes in a regulatory gene brought about by transposable elements have profound effects on the anatomy and physiology of the adult. They may alter gene expression in time or space and also may act as mutagens (Cost and Boeke, 1988). L1, a common transposon in mammals, can transfer independently and has a role in enabling other elements to move around the genome, *e.g.* SINEs such as Alu (Jurka, 1998). Such changes would have to be suppressed until the right time and also be more likely to occur and spread throughout the population during environmental circumstances that would favour an increase in their frequency. Retroviral-like elements are the one kind of DNA with known regulatory functions that show these characteristics (McDonald, 1990). Insertion causes major changes in the pattern of gene expression and at the same time they are capable of being suppressed by the action of protein-coding DNA (chromosomal genes). Stresses of various kinds increase retroviral activity (see Box 7). This occurs in almost all types of mutation in bacteria. These mutations accumulate in a non-random manner and could be implicated in major bursts of morphological diversity in the fossil record which are usually associated with stressful environments (Lewin, 1983).

There is one report of the acquisition of regulatory sequences from a retrotransposon, the Slp gene in mice (Robins and Samuelson, 1992). Multigene families also have an important role in diversification of populations. Many contain pseudogenes which means that new combinations could be synthesised repeatedly by recombining basic domains, much as occurs in the generation of antibody diversity in chicken and rabbit (see Box 5).

Amplification and movement of retroviral elements have been implicated in genomic rearrangements in hybrids that facilitate reproductive isolation in species of marsupials. This could bring about enormous changes in DNA structure and gene regulation. The same variation does not occur in other mammals and so the authors suggest that there are a variety of mechanisms for diversification (O'Neill, 1998). Comparison of LINE sequences in Murinae found that LINE amplification coincided with radiation within this subfamily. Here we see diversity inherent in the early members of this group being expressed by the multiplication and movement of these sequences of non-coding DNA (Furano and Usdin, 1995). Retroposon movement is probably happening today, as evidenced by reports of reverse transcriptase found today (*e.g.* Kim *et al.*, 1990; Moran *et al.*, 1999, Sassaman *et al.*, 1997; Naas *et al.*, 1998).

A model of biblical creation readily incorporates such observations. There must have been world-wide environmental changes during and after the Flood. Large scale extinction and changes in habitats would leave enormous 'gaps' in the ecosystems of the world. The mechanisms for generating variability described above may well have been involved since those times, utilising the genetic material already available. However, a careful study of the population genetics of possible models is necessary. We can also expect to find degradation of originally created designs. The loss of an acute sense of smell in humans is one possible example, as we now possess a number of inactive odorant receptor genes (Rouquier *et al.*, 1998). Other possible examples are the loss of a functional gene in humans and guinea pigs to synthesise vitamin C (Ohta and Nishikimi, 1999) and loss of galactosyl transferase (Galili and Swanson, 1991). I would like to suggest that firstly loss of genetic material by mutation, by extinction of populations and secondly changes by recombination of pre-existing genetic material, gene conversion (repair), altered regulation of pre-existing genes and timing of activation could have brought about substantial differences in morphology within the basic kinds without any need to invoke *de novo* synthesis of the DNA coding sequences.

Junk DNA—use in tracing supposed evolutionary pathways

There are a number of examples of the same (or very similar) processed pseudogenes described in different species or even different orders. There are examples of shared pseudogenes for human and various primates (*e.g.* Battey *et al.*, 1982; Craig *et al.*, 1991; Kawaguchi *et al.*, 1992) and for cetaceans, ruminants and hippopotamuses (Maueler *et al.*, 1992). There are also examples of similar endogenous retrovirus in the literature (*e.g.* Dangel *et al.*, 1995; Johnson and Coffin, 1999; Svensson *et al.*, 1995). Comparisons of the 7 Alu sequences in humans and chimpanzees in a cluster of α globin gene has found them present at the same place and so common ancestry is claimed (Sawada *et al.*, 1985). However, it should be remembered that there are roughly one million copies of this sequence in the human genome. Separate insertion of the same sequence in the same place must be considered a possibility.

Max (2000) argues that when the same errors are found in two types of organisms it indicates copying. The possibility of two identical errors (mutations) occurring separately in two animals is considered 'so unlikely that it can be dismissed'. Therefore it is assumed to have occurred in a common ancestor and the error passed down the generations in the evolving species. However, direct copying, as for example in textbook plagiarisation (see introduction) and the similarities in DNA between groups of organisms are not comparable for a number of reasons:

1. The error in print is neutral and would lie unnoticed in the records whereas it is possible that the genetic material has some function. To say that no role is known is quite different to saying that it has been shown by scientific research methods that there is no function. In these days of the human genome project researchers are often more interested in describing sequence than in spending time checking whether each section has a function. At the moment there is some evidence indicating roles.
2. The fundamental problem, in common with many aspects of evolution, is to demonstrate a mechanism by which neutral genetic changes can be spread to all members of a group. For example, if a processed pseudogene appears in a population, it must first spread throughout this ancestor population and then be carried into a newly evolving species. Some models have been proposed, but evidence is awaited (Dover, 1982; Elder and Turner, 1995). However, if functions are found for such pseudogenes, their presence in more than one group is to be expected.
3. Mutations are not entirely random events, but more akin to the likelihood that you stub your big toe and that is related to your three dimensional structure. The genome is a complex three-dimensional organelle as has been discussed. More than that, only those sections that are active in the germline are vulnerable to mutational events, such as processed pseudogene formation.
4. There is an increasing amount of evidence that insertion of transposable elements is not random. Examples are Alu sequences (Bernardi *et al.*, 1985; Muenier-Rotival *et al.*, 1982; Soriano *et al.*, 1983; Wichman *et al.*, 1992) and mobile elements in *Drosophila* (Gerasimova *et al.*, 1985). Over half of the L1 sequence sites in humans have elements in equivalent positions in other mammalian genomes (Smit *et al.*, 1995). Therefore, it would not be surprising if a few transposable elements were identical when comparing primate species and man. Elements of particular composition tend to cluster in areas of DNA with similar base composition. More than that, there are patterns of transposable element occurrence and amplification that cannot be explained by an evolutionary tree. The insertions are thought to have happened independently in different animals, *e.g.* rabbit and humans (Hardison *et al.*, 1991). Clearly, there are 'hotspots' for insertion (see discussion in von Sternberg *et al.*, 1992). This is also the conclusion from studies of human diseases caused by mutations (Eyal *et al.*, 1990, and Youssoufian *et al.*, 1986). Over half of the breakpoint junctions in human germ cell rearrangements of genes are in the α- and β- globin gene clusters (Kornreich *et al.*, 1990) with the frequent involvement of the Alu sequence family at breakpoint junctions. Human cells possess the enzyme required for re-insertion of transposable elements, which means that viruses are not the only way re-insertion occurs and may not be the principle route (Tchénio *et al.*, 1993). L1 is known to be responsible for the transcription of a range of different transposable elements (Smit, 1996). More than that, the enzyme, L1 endonuclease, has preference for certain sequences when nicking to make insertion sites (Cost and Boeke, 1998; Jurka, 1998). This is hardly surprising, given that most enzymes have preferences for sites at which they will function. Similarly, retroviruses in man

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(1) Frequency of insertion into the chromosomes increases under environmental stresses in yeast (McEntee and Bradshaw, 1988).

(2) Temperature, chemical and radiation stresses can activate various dormant retroviral-like elements in *Drosophila*, the fruit fly (Strand and McDonald, 1989; Hennig *et al.*, 1989).

(3) Activation by radiation and viral infection in mammals (Coffin, 1984).

(4) Activation by heat stress (Fornace *et al.*, 1989).

(5) Retrotransposon VL30 in mice can become active in cells in response to certain natural hormones (gonadotrophins, glucocorticoids), to chemical carcinogens and anoxia (Schiff *et al.*, 1991).

Box 7: Effects of stresses on retroviral activity

have unique and markedly different integration patterns (Taruscio and Manuelidis, 1991) with microsatellites having a role as retroposition 'navigators' (Nadir *et al.*, 1996). These preferences can explain the presence of similar transposable elements, such as processed pseudogenes, in similar or the same places; there is no need to invoke a common ancestor.

5. If these mutation events were the product of evolution millions of years ago, then divergence of the sequences would be expected along with evolutionary changes in the rest of the genome. The lack of such change indicates a function for the sequences. Function indicates an original design.

There are many examples of conflicting results when comparing evolutionary trees constructed using different information. For example, Murinae, a rodent subfamily is based on certain dental and skull characteristics. From comparison of a LINE sequence in the members of this subfamily, three orders must be excluded and evolutionary convergence of the dental pattern accepted (Furano and Usdin, 1995). Charlesworth *et al.* (1994) agreed that there are several examples of such problems and suggested that transfer of transposons could occur across species barriers. Here we have examples of conflicting evidence for evolutionary pathways from biochemical and structural information. The facts provide evidence for separate design of different animal and plant groups with similarities in design seen within similar groups.

In Conclusion

Non-coding DNA is not a random assortment of DNA, it is recognisable as several clearly identifiable types and many have known functions discussed above. There are structural roles, lengths of DNA acting in the same way as a skeleton and there are regulatory roles, affecting the amount, timing and site of action of genes. Some pseudogenes have no known role at the moment, other pseudogenes appear to be functional, but their role is not yet known and others may be degenerate DNA. Many have been identified as part of the human genome project and possible roles are likely to be investigated at a later date. Yet other types of non-coding DNA are known to be responsible for causing diseases and can be regarded as degenerate DNA. Evidence is entirely consistent with a model of biblical creation with coding of original designs for the created kinds that included in-built variation. This variation would enable speciation to occur and colonisation of new and different habitats after the Flood.

Acknowledgement

I would like to thank Marc Surtees and Elizabeth Cardno for their helpful comments on an earlier draft.

The Author

Dr. Darrall is one of our editorial team and has frequently contributed to the journal over the years. She is one of our experienced speakers on creation-evolution issues. Her academic training has been in Agricultural Botany (BSc), Pure Botany (PhD) and Speech Therapy (MSc). Current areas of interest are fossil botany, junk DNA and mitchondrial DNA.

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Butterfly Wings—a Case for Design?

RECENT years have seen increasing research into the wings of butterflies. The results are often staggering. Consider their colours. Many of these arise from pigmentation—and that requires its own discussion as to the causes and reasons—but some of the scales are free of pigment and yet iridescent. The scales are made of a chemical, chitin, similar to dry human skin and which is colourless.

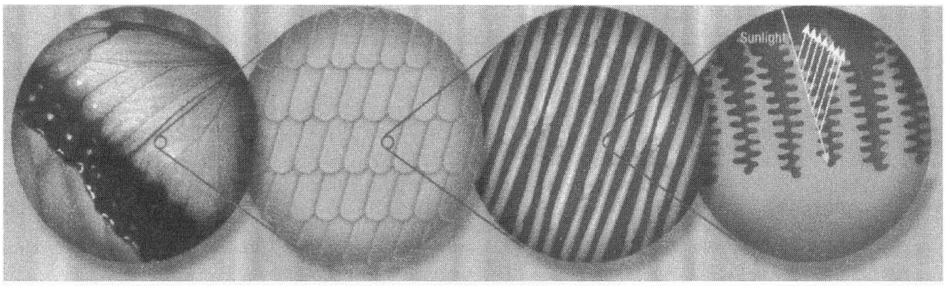


Figure 1: Detail of a butterfly wing and reflections to give iridescence. (From photograph by Oxford Scientific Films in New Scientist, *26 June 1999.)*

Scientists at Exeter University have been studying the bright green colour of the wing scales of the Indonesian *Papilio palinurus* butterfly. They find that it is a combination of yellow and blue iridescence generated from the microscopic layers in the butterfly. Butterfly wings are made up of scales which have a very fine structure. For example, in the scales there are ridges, giving a corrugated effect. Each ridge has a structure which Prof. Roy Shambles and Dr. Peter Vukusic describe as a Christmas Tree effect (see figure 1).

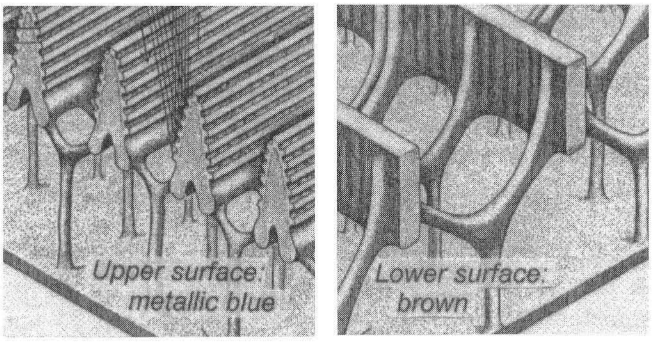


Figure 2: The different reflecting surfaces of the Morpho rhetenor *butterfly (from W. Gitt,* In the Beginning was Information*).*

Different structures give differing reflections. The South American butterfly, *Morpho rhetenor* has a metallic blue colour to its upper wing surface and brown to its lower surface (see figure 2).

A news report from the University of Toronto claims that ultrasound-sensitive ears evolved as nocturnal defence mechanisms. Professor James Fullard and Dr. Jayne Yack, studied the species *Macrosoma heliconiara*, a Panamanian butterfly. These fly by night but manage to evade bats by taking steep dives, climbs or loops. It was proposed by these researchers that the butterflies must have evolved some sensitive ultrasound detection system. They found ears on the wings (figure 3). What happened to all the butterflies that lacked the ear before it evolved is not disclosed! Nor how this structure is supposed to have developed. Again, it looks more like a design feature.

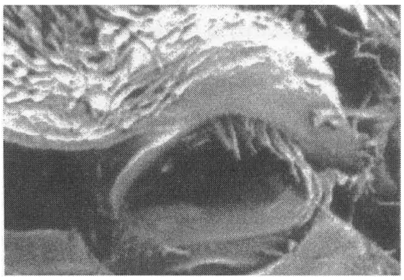


Figure 3: Ultrasonic wing-based ear of Macrosoma heliconiara.

Another fascinating insight into the working of the wings is a study of the butterfly at rest. As you will have noticed, they hold their wings vertically together above their bodies. To fly away, they have to move the wings apart. This creates a region of reduced pressure between the wings and would make it hard to move them quickly into the flying mode. As seen in figure 1, the scales are arranged like tiles on a house roof. At the point of attachment, they are hinged so allowing the scales to move away from the surface. As a result, when the wings begin to move, the scales move outwards, release the air beneath them and so compensate for the loss of pressure.

These are but three recent aspects of research into the butterfly wings. How much more is there to be found? You can be sure that it will make you marvel at the work of the Creator who built these features into the butterflies.

J.H.J.P.

The Then World with Water having been deluged Perished

Steven J. Robinson

THE GEOLOGY of the present earth is such that it is difficult to conceive of processes, however cataclysmic, that could result in the global flood described in Genesis 7–8. Given that such an event once occurred, a possible solution may be that the original earth was not the same as that which now exists. It might have been differently constituted. As a result of the cataclysm it might even have been totally destroyed. The inability of diluvialists to explain the geological record on the basis of current concepts suggests that a radical re-think is called for.

It is perhaps an unfamiliar notion that fresh understandings of Scripture can come about through failed attempts to reconcile it with actuality. Nonetheless, such failures are a necessary part of the process by which one acquires wisdom—in one's spiritual life as much as in matters of science. Often, actuality does not fulfil our expectations of how things ought to be, and this non-fulfilment can be perplexing, even painful. We are forced to re-evaluate what Scripture is telling us. Is this or that understanding really the meaning? If it is, have I really understood how it applies to the present situation, or problem? True faith is not merely exercised, it is also learned. And inasmuch as our ideas about what is true are 'conjectures', one learns as much through 'refutations' of them as through confirmations.

The problems that arise when one attempts to reconcile Genesis 7–8 with the geological record are a case in point. In addition to the difficulties presented by the text itself, there is a host of extra-biblical data that seem to cast doubt on the idea of a recent, global flood—at least so far as the Phanerozoic is concerned. Examples include the absence of any trace of a pre-Flood civilization, the non-appearance of human fossils until the Pliocene, the generation of Precambrian and Phanerozoic stromatolites, the generation and geographic distribution of fossil fuels, biogenic carbonates, in-place reefs and encrusted hardgrounds, evolutionary lineages, the geographic distribution and chronostratigraphic order of fossils in general (including the belated appearance of flowering plants), the fossil track record, successions of dinosaur egg clutches, cycles of mountain-building and erosion, the consumption of the entire ocean floor prior to the Jurassic, and the cooling of oceanic waters through the Tertiary. Such features falsify all attempts to identify the Flood with any part of the Phanerozoic—the fossil record after the Precambrian. Thus, having satisfied oneself that the problematic data are real, one is driven to inquire whether one has understood the text correctly.

At the Fourth International Conference on Creationism two papers examined some crucial issues relating to the interpretation of the scriptural record. The first, by David Fouts and Kurt Wise (1998), examined the meaning of three key words: *machah* ('blot out'), *tehom* ('deep'), and *mayan* ('fountain'). They concluded:

- The use of *machah* throughout Scripture, as well as the theology of the blotting out of sin, argues against its meaning the complete obliteration of something without evidence.
- *Tehom* may refer to both terrestrial and oceanic waters.
- *Mayan* may denote either a terrestrial or an oceanic spring.

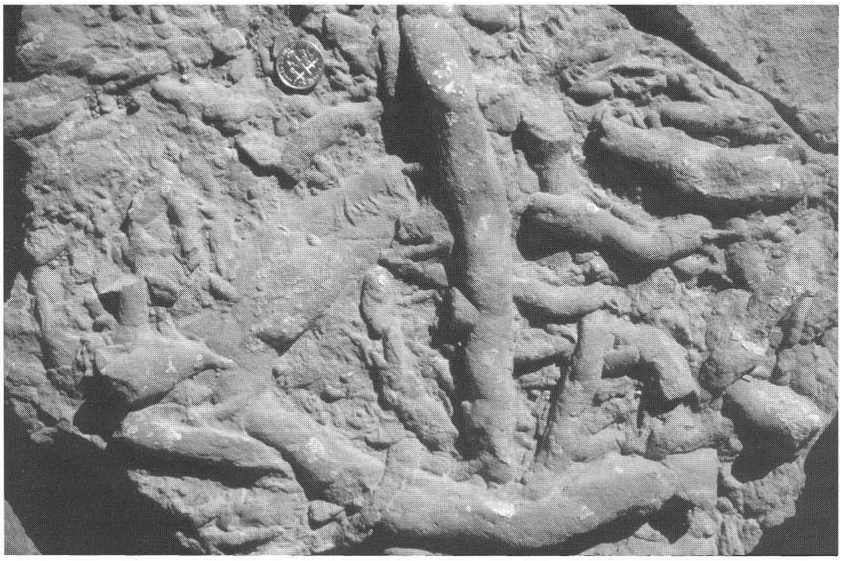
Accordingly, since the text said that all the fountains of the deep broke open at the beginning of the Flood, these must have been both terrestrial and oceanic springs. The other paper, my own (Robinson, 1998a), also addressed these issues, along with the chronology of the events recounted and the location of the mountains of Ararat. The present paper will examine the arguments deployed by Fouts and Wise and, in so doing, present a fuller discussion than that attempted at the ICC.

The meaning of *machah*

In Genesis 6:7, 7:4 and 7:23 *machah* is the verb used to signify the blotting out of all animals from the face of the earth. The crucial question is: do these verses allow of the possibility that some of the animals might have been preserved as fossils?

Fouts and Wise analysed the 36 occurrences of this word in the Old Testament under five headings: to blot out as from a book, to blot out the name or memory of a people, to blot out sins, to wipe (*e.g.* a dish or a face) and to blot out in the general sense of destroy. Apart from this last heading, the purely linguistic analysis is uncontroversial, and confirms that the basic meaning is to wipe, wipe away, or erase. My main reservations concern the accompanying commentary.

1. 'Although such a blotting process may have been intended to leave no evidence, often evidence did remain of something having been obliterated.' This remark derives not from linguistic analysis of specific uses of the word but from knowledge of ancient writing materials. It could equally apply to modern writing materials. Traces of chalk usually remain when a



Multi-level burrowing in the Tapeats Sandstone, Grand Canyon (Lower Cambrian). Such examples of life going on normally are irreconcilable with the idea that a violent, global deluge was occurring at the time.

teacher wipes a blackboard, for example. Some indentations and traces of pencil lead usually remain when one rubs writing from a piece of paper. The intrinsic meaning of 'erase', or of *machah*, is not affected by these observations.

2. Exodus 17:14 and Deuteronomy 25:19 speak of the blotting out of the remembrance (not name) of Amalek—in the first instance as part of a promise, in the second as part of a command. Fouts and Wise say that while definite artifactual evidence of the existence of Amalek may be lacking, some evidence of their cities probably remains. In fact, one could go further and argue that traces of one such city do remain—Tell el-Ajjul, which many archaeologists identify with the Sharuhen of some Egyptian texts (Weinstein, 1991) and which could have been 'the city of Amalek' in 1 Samuel 15:5 (Robinson, 1995). Tell el-Ajjul has been excavated and artefacts and bones belonging to its Middle Bronze Age occupants have been recovered. What Fouts and Wise overlook, however, is that blotting out the remembrance of a people and destroying their artefacts (as in 1 Samuel 15:3) are not one and the same. The remembrance of a people could be extinguished without the total obliteration of their possessions, and there is no reason to think that, by say the 9th century BC, anyone could remember the Amalekites (*cf.* 1 Chronicles 4:43). As evidence of just how absolutely God intended the destruction of a nation whose remembrance was to be blotted out, one need only turn to Psalm 9:5–6, which says:

   > Thou hast rebuked the nations, destroyed the wicked;
   > thou hast blotted out their name for ever.
   > The enemy have vanished in everlasting ruins;
   > their cities thou hast rooted out;
   > the very memory of them has perished.

3. Isaiah 44:22 states that 'I have blotted out your transgressions like a cloud, and your sins like mist.' Fouts and Wise comment: 'By analogy, a recently dispersed cloud or mist can at least potentially be evidenced by dampness or dew on the ground or vegetation. Theologically, although provision for sin itself has been made by atonement (a covering over), by forgiveness, by propitiation, by removal, and by blotting out, evidences of that sin usually do persist. ... The blotting out of sin appears to remove sin completely out of a book of judgment, but not necessarily out of memory.' Again, the argument misses the point. The question is not whether 'evidence' of the transgressions is blotted out, but whether the transgressions themselves are. Although the sin of David's adultery with Bathsheba is forever recorded in the book of 2 Samuel, the sin itself, so far as God is concerned, is completely blotted out, as a result of David's repentance and God's forgiveness. Similarly, the only certain evidence of the men and animals who lived before the Flood is the record of them in Genesis. Since Genesis says that all flesh on the earth was blotted out, there is no biblical reason to expect that their bodies should persist in any form.
4. 2 Kings 21:13 states that God will stretch over Jerusalem the measuring line of Samaria (which had already been destroyed by the Assyrians) and will wipe Jerusalem as one wipes a dish, wiping it and turning it upside down. Fouts and Wise comment: 'Evidence for this destruction has been archaeologically verified on numerous occasions.' Unfortunately, they neglect to say where they identify Nebuchadrezzar's destruction of Jerusalem in the archaeological record. The chronological framework imposed on that record by most archaeologists results in a mismatch with biblical history (James *et al.*, 1991; Rohl, 1995). Consequently, evangelical scholars should be slow to believe that, for instance, the wall which the Israeli archaeologist Nahman Avigad brought to light in the Jewish Quarter was that destroyed by the Babylonians; in all probability the wall was built by Nehemiah, of which, according to Avigad, unaccountably 'few traces' survive (Avigad, 1983). The excavated wall was built over the ruins of the dwellings of the common people, which the Babylonians seem to have spared. According to 2 Kings 25 they burned down the Temple, the king's house, and 'all the houses of Jerusalem', that is, 'every great house'. 2 Chronicles 36:19 records the same thing, as does Lamentations, which refers to the destruction of Israel's palaces, strongholds, walls, and gates. 2 Kings 21:13 does not, however, say that Jerusalem itself would be obliterated, but rather, as the next verse makes clear and as was later to happen (2 Kings 25:11), Jerusalem would be wiped clean of its inhabitants. Fouts and Wise have simply misunderstood the text.
5. Four passages are cited as evidence that *machah* can be used in the more general sense of destroy: Nehemiah 13:14, Proverbs 6:33, Ezekiel 6:6 and Proverbs 31:3. The contention is not sustainable, however. Nehemiah 13:14 is entirely in line with uses which refer to the blotting out from a book. Proverbs 6:33 states that the disgrace

of the adulterer will not be wiped away—a metaphorical use of *machah* similar to the concept of blotting out sins from a book of judgment. Ezekiel 6:6 states: 'Wherever you dwell your cities shall be waste and your high places ruined, so that your altars will be waste and ruined, your idols broken and destroyed, your incense altars cut down, and your *works* wiped out.' Fouts and Wise comment: 'Though the idolatry itself was blotted out by God, evidence of this former idolatrous worship still exists.' This archaeological argument is subject to the same uncertainties as relate to the destruction of Jerusalem and misunderstands the Hebrew. Ezekiel says that the idols and altars would be destroyed (not necessarily obliterated) and their works wiped out. As in English, although 'works' can denote physical works, primarily it means deeds or labours (Genesis 5:29, 20:9, 44:15 *etc.*), which may or may not result in physical works (*cf.* Exodus 23:24). Finally, Proverbs 31:3b speaks of kings being wiped out as a result of giving their strength to women (31:3a). While the context is a guide to determining how *machah* is used here, it is also true that the normal meaning of *machah* must be heeded in determining what the verse as a whole means. The synonymous parallelism as well as considerations of best sense indicate that the controlling context is 31:3a, so that the reference is to extermination of the royal line. By contrast, Fouts and Wise suggest that the sense should be understood from 31:4–5 and understand 31:3b as a warning that drunkenness will lead to loss of royal position. But verse 5 does not say that kings themselves will suffer from their being addicted to strong drink, but that their subjects will.

Fouts and Wise repeatedly presuppose that those who wish to dissociate the Flood from the macrofossil record interpret *machah* to mean obliterate 'without any evidence remaining'. Then they show that whenever one can deduce the fate of that which was obliterated, evidence of its previous existence or of the agent of its destruction might have remained, and probably did remain. From this they conclude that proper exegesis contradicts the interpretation of complete obliteration 'without a trace'.

This is a *non-sequitur.* 'Evidence' is not tantamount to 'trace'. Although a footprint or a birth certificate may constitute evidence that a body exists, they do not constitute the physical remains of the body. None of those criticised has ever suggested that *machah* means to obliterate without 'evidence' of the destroyed thing or destroying event. What has been argued is that *machah* means 'wipe' or 'wipe out', and that the use of this word in Genesis entails that all flesh during the Flood was totally expunged from the earth. Gordon Wenham picks up the emphasis when he writes: 'Since water was sometimes used for achieving this result (Numbers 5:23), the very word chosen perhaps hints at how the complete annihilation of mankind will be secured.' (Wenham, 1987)

One could, of course, argue that in practice the action of wiping something clean often does leave traces behind—for example, chalk dust left on a blackboard. However, this is a point about the efficacy of certain actions, not about the meaning of 'erase' or 'wipe out', which still conveys the sense of something disappearing. Nor does one do justice to the quality of the fossil record to characterise all terrestrial fossils as mere traces. Dead terrestrial animals today very rarely turn into fossils, but return to the dust from which they came. By contrast, a well-preserved fossil is the nearest thing, in this world, to immortality. The amphibians and reptiles from Archer County, Texas, the birds, crocodilians and dragonflies from Solnhofen, the mammals from Messel complete with hair and stomach contents, evoke wonder and delight, not sober reflection on past and future judgment. To suggest that fossils are 'evidence of His holiness *etc.*' because they testify of the Flood is to beg the question—whether they are, in fact, remains of animals destroyed in the Flood.

Cast of a man buried under ash during the eruption of Vesuvius in AD 79; Stabian Baths, Pompeii. Why do we find no similar traces of human beings killed in the much greater catastrophe of Noah's Flood?

In Genesis 6:7 and 7:4 *machah* is coupled with the phrase 'from the face of the ground' and in Genesis 7:23 with the phrase 'from the earth'. The nearest grammatical parallels in the Old Testament are therefore passages which include a phrase stating that something was blotted out 'from' or 'out of' something. These are Exodus 17:14, Deuteronomy 9:14, 25:19 and 29:20 (from under heaven), Judges 21:17 (from Israel), Exodus 32:32f and Psalm 69:28 (out of a book), Nehemiah 4:5 and Jeremiah 18:23 (from God's sight), and Isaiah 25:8 (from the face). These are also the nearest semantic parallels: the object of the verb being the thing wiped away, not the thing wiped. (The English word works in the same way: contrast 'he wiped her face', for example, with 'he wiped the tears from her face'.) In no case is there any suggestion that we should entertain the possibility of traces remaining.

The entry for *machah* in the *New International Dictionary of Old Testament Theology and Exegesis* (NIDOTTE) summarises the range of meaning as follows:

1. … Erasing from a scroll was normally effected by washing, and this action appears to be a basic meaning of *mhh*. Since wiping off or out implies the complete

> removal of whatever is in view, *mhh* is often used with great effect for both Yahweh's judgment and salvation.
>
> 2. In terms of judgment, the verb is employed to describe the complete removal (and thus destruction) of life by the Flood, the complete obliteration of the memory of Amalek, and the total removal of the name of the wicked generally. …
> 3. In terms of salvation, *mhh* is used in the promise of God's wiping away tears from all faces and the assurance that sins have been wiped out. (Van Dam, 1997)

One cannot help asking why Fouts and Wise are driven to conclusions markedly at variance with this authoritative analysis, which they do not cite. The obvious answer is that the geological model favoured by Wise (Austin *et al.*, 1994) demands different conclusions. As I have had occasion to observe before (Robinson, 1998b), the paradigm constrains the interpretation of Scripture, rather than vice versa.

The location of 'the deep' *(tehom)*

The authors begin their discussion by noting that *thm*, the Ugaritic equivalent of the *tehom*, means 'ocean' or 'deep'. Likewise, *Ti'amat*, according to Alexander Heidel, is an Akkadian cognate meaning 'salty sea'. (Akkadian was the language of Babylonia and Ugaritic the language of Ugarit, on the coast of Lebanon. Ugarit was closely related to Hebrew, Akkadian less so.) Heidel, however, writes:

> *Ti'âmat*, as we have seen, is a mythical personality. Such significance the Old Testament *t^{e}hôm* never has. It is nothing but a designation for the deep, the sea, the ocean, or any large body of water. … But while *t^{e}hôm* stands for the entire body of water, *Ti'âmat* represents only one *part* of it, the other part being represented by *Apsu*' (Heidel, 1963).

The idea is that *Ti'âmat*, a female deity, personified the waters that surrounded the land, while *Apsu*, a male deity, personified the waters under the land. However, the Akkadian (Babylonian) myth is more complex than this, since in the beginning the waters of *Ti'âmat* and *Apsu* were all commingled. Later, *Apsu* is slain and his body becomes the home of various gods: he is depersonified and becomes a place, the *Apsu*. Then *Ti'âmat* is slain. Her body is cut in two: half of it becomes the waters shut up above the sky, the other half the earth and its waters. Clouds, wind and rain are produced from her spittle, from her eyes the Tigris and Euphrates are opened, springs gush forth, mountains are piled up from her udder. Thus it is far from clear that the concept of ocean or sea *(tiamtu)* excluded the *Apsu*, the abyss under the land.

In Hebrew, as in Ugaritic (Hasel, 1974), there is no cognate of *Apsu*. The concept of a watery abyss was included in the word *tehom*, a body of water which both encircled the land and lay underneath it. This is in contrast to our world-view, where the rivers originate from rainwater and the ocean is separate from any bodies of water within or under the earth.

Fouts and Wise claim that of the 36 occurrences of *tehom* in the Old Testament most refer to oceanic depths, distinct from subterranean waters. Much of their case rests on the argument that in many instances *tehom* appears as either synonymously parallel with, or explanatory of, the term *yam* (sea). However, even if this were true, 'synonymously parallel with' is not the same as 'synonymous'. As pointed out by Tremper Longman,

> The emerging consensus is that the parallel line is a more subtle literary device than previously thought. The new paradigm for understanding parallelism is development rather than equivalence. The biblical poet is doing more than saying the same thing twice. (Longman, 1997)

In antithetic parallelism the first and second lines contrast with each other. In synthetic parallelism the second line develops or completes the thought of the first. Even in synonymous parallelism the two lines rarely say precisely the same thing. It is thus illegitimate to use this sort of analysis to infer the precise meaning of a word.

Identifying what kind of parallelism controls the structure may depend on establishing what the word means first, and at best, will simply enable the range of possible meaning to be narrowed down. Take, for example, Psalm 106:9.

> He rebuked the Red Sea, and it became dry;
> and he led them through the deep as through a desert.

This is synthetic parallelism because the second line develops or completes the thought of the first. In particular, *tehom* (deep) is synonymously parallel with *yam* (sea), because the words denote the same object. However, although *tehom* and *yam* are evidently very close in meaning, it does not follow that *tehom* means *yam*, or that *yam* means *tehom*, or that English 'sea' means precisely the same as Hebrew 'sea'. Likewise, Psalm 135:6 says:

> Whatever the Lord pleases he does,
> in heaven and on earth,
> in the seas and all deeps.

Here 'deeps' seems to denote something distinct from 'seas', just as 'heaven' denotes something distinct from 'earth'. Likewise in Job 28:14, in answer to the question where wisdom shall be found:

> The deep says, 'It is not in me,'
> and the sea says, 'It is not in me.'

The places are different, just as in the next verse gold and silver are different.

Fouts and Wise go on to cite Psalms 104:6 and 148:7, Job 41:31, Proverbs 3:20 and 8:27–28 as examples of *tehom* referring to oceanic waters (English sense), since the immediate context is the waters and seas of creation. This is largely true of Job 41:31. Psalm 104:6, however, refers to the deep before the emergence of dry land, and is not therefore relevant. Psalm 148:7 says:

> Praise the Lord from the earth,
> you sea monsters and all deeps …

Here 'sea monsters' translates *tanninim* and, in view of the close parallel in Psalm 135:6, seems to stand for 'sea' (*yam*). Hence—*pace* David Tsumura (1989)—'all deeps' probably signifies uninhabited bodies of water distinct from the waters around the land. Proverbs 3:20 is decidedly contrary to Fouts and Wise's interpretation. Along with 3:19 it reads:

> The Lord by wisdom founded the earth;
> by understanding he established the heavens;
> by his knowledge the deeps break forth,
> and the clouds [*or* skies] drop down the dew.

Here the parallelism is both synonymous and antithetic:

wisdom being similar to understanding, earth contrasting with heavens. It is also synthetic, inasmuch as the breaking forth of the deeps expands on what the earth means for man and the clouds dropping down dew expands on what the heavens mean for man. The deeps here refer to sources of water that spring out of valleys and hills (Deut 8:7) (Seely, 1997), watering the earth from below just as the dew waters the earth from above. Proverbs 8:27–28 has a similar structure.

Thus, Fouts and Wise are incorrect in concluding that *tehom* most often refers to oceanic depths distinct from subterranean depths. On the other hand, they accept that in some passages *tehom* either refers or seems to refer to underground sources of water—thus Genesis 49:25, Deuteronomy 8:7 and 33:13, Psalms 42:7 and 78:15, Ezekiel 31:4 and 31:15, and Amos 7:4. I would add Psalm 71:20 and Habakkuk 3:10, which they consider ambiguous. In speaking of 'the deeps of the earth', Psalm 71:20 is alluding to the waters of Sheol, which lay within or under the earth.

Painting on the stone Tomb of the Diver, Pæstum, c.480 BC. The soul plunges into the waters of death under the earth. Note the trees on each side of the water.

Isaiah 44:27 describes God as saying to the deep, 'Be dry, I will dry up your rivers,' and is also in keeping with these passages. Fouts and Wise claim to identify two 'major problems' with the view that the deep here refers to subterranean waters.

One is that the term used is not *tehom* but a probable synonym, *sula*. But if *sula* is synonymous with *tehom*, there is not a problem, since the words denote the same thing. Indeed, the authors may themselves be found arguing from a passage where a synonym rather than the word in question is used. In that instance, however, (Job 38:16, discussed below) the apparent synonym is of uncertain meaning, since it occurs nowhere else, and they endow it with a meaning at odds with the way in which the word in question is used. Here, by contrast, the association between *sula* and rivers is in keeping with other verses where *tehom* and rivers are associated (Deuteronomy 8:7, Psalm 42:7, Ezekiel 31:4 and 31:15).

The other alleged major problem is that Isaiah 44:27 occurs in a salvation oracle which (it is said) resonates with allusions to the Exodus, and one would be thinking of God drying up the Red Sea at this point, as well as the Jordan. Again, the reader should judge the merit of this objection by considering the text itself (Isaiah 44:24–28). Anyone who reads the statement 'Be dry, I will dry up your rivers' as a reference to the Exodus, when the Red Sea was dried up, is missing the point. This is a prophecy, looking forward to the day when God will restore the Jews exiled in Babylon to their homeland. He promises that the cities of Judah and the temple of Jerusalem will be rebuilt, through a man called Cyrus. At the same time, somehow associated with this restoration, rivers will be dried up. An account of Babylon's fall may be read in Herodotus (1954). Before reaching the city, Cyrus, king of Persia, decided in a fit of rage to split the river Gyndes into hundreds of separate channels, so that it could be crossed without even wetting the knees. Likewise, he captured Babylon by diverting the river which flowed through the city. With the water no higher than their thighs, his soldiers were able to pass along the river bed into the city while its occupants, unaware of what was going on, were celebrating a festival.

Fouts and Wise state that because several biblical passages seem to associate the oceans with the foundations of the mountains and of the world (actually the earth, *i.e.* the dry land), three commentators have recently argued that the 'great deep' in Amos 7:4 refers to oceanic waters (English sense). The authors do not state whether they concur—possibly not since they list Amos 7:4 among the passages which seem to refer to underground sources. In any event, the only cited commentator who writes at any length on the question has been misunderstood. Douglas Stuart writes:

> Since the 'foundations of the mountains' are sometimes visualised as being rooted in the depths of the sea (Jonah 2:6, Ps 46:2), as are the 'foundations' of the earth (2 Samuel 22; Psalm 18:16; Proverbs 8:29; *cf.* Micah 6:1–2), the image of fire devouring the 'deep' therefore fits closely the depiction in Deuteronomy 32:22: fields and sea are devoured in both descriptions. (Stuart, 1987)

The devouring of the deep by fire is closely associated with the devouring of the earth by fire, because the earth was considered to be founded in the deep[1]. Likewise Smith and Page state that 'the great deep' here refers to 'subterranean waters that feed the springs' (Smith and Page, 1995), as does Michael Grisanti (1997) in NIDOTTE. These opinions depend on studies of *tehom* in other contexts, since little can be learned from Amos 7:4 by itself.

Psalm 24:2 categorically states that the earth was founded upon the seas and established upon the rivers—'seas' as in Genesis 1:10, 'rivers' as in Genesis 2:10, 13 and 14. Fouts and Wise claim that the verse may mean simply that the land is at a higher elevation than the sea, and advance the same interpretation for Psalm 136:6, which says that God spread the earth upon the waters—he spread the earth so that it was at a higher elevation than the waters. The implicit contention is that this must be the meaning of Psalm 24:2, however vacuous, because the present earth is known not to be founded upon the seas. As Paul Seely (1997) observes, this is to base interpretation on the conceptions of modern science rather than historical and grammatical exegesis (*cf.* 2 Peter 3:4). The primary meaning of the preposition *al* is 'upon' and translated thus by all the major English translations. All other occurrences of the verb *yasad* ('found' or 'set') with *al* require the same sense (Psalm 104:5, Canticles 5:15, Amos 9:6).

Likewise, Fouts and Wise cite Mitchell Dahood to validate the suggestion that 'seas' in Psalm 24:2 refers to oceans and 'rivers' to ocean currents, since Dahood renders *nahar* as 'ocean currents' in his translation. However, as with Amos 7:4, the authors have missed the point, for the 'ocean currents' here are to be understood as running under, not around, the land. Dahood expressly says that the earth is pictured as resting on pillars sunk into the subterranean ocean (Dahood, 1966), and repeats the point in his gloss on Psalm 136:6—'the earth was thought to rest upon the subterranean abyss of waters' (Dahood, 1970). The remark by Peter Craigie is also apposite:

> Dahood translates 'ocean currents,' with reference to Ugaritic (Psalms I, 151). But Ugaritic does not clearly support such a translation, and elsewhere Dahood has recognised the more appropriate translation of Ugaritic *nhr*, namely 'river,' or perhaps 'river current'. (Craigie, 1983)

In yoking seas and rivers together the verse nullifies the modern distinction between salt and fresh water bodies. In the Hebrew mind the seas of Genesis 1:10 were both around and under the land (*cf.* Job 38:16, discussed below); the rivers which nourished trees were the surface continuations of subterranean rivers (Ezekiel 31:4,15). A similar association between seas and subterranean abyss (= *tehom*)[2] carries over into the New Testament (Revelation 11:7, 13:1).

The location of 'fountains' (*mayan*, pl. *mayenot*)

Analysing this word in context, Fouts and Wise identify just two occurrences—out of twenty three—where the normal meaning of a terrestrial spring might be called into question: Proverbs 8:24 and Job 38:16.

The occurrence in Proverbs is excepted on the grounds that the succeeding verses seem to refer to Day 2 of Creation Week, well before the appearance of land and the gathering of the waters into one place on Day 3. Is this true? The text reads:

> When there was no deep I was brought forth,
> when there were no fountains abounding with water.
> Before the mountains had been shaped,
> before the hills, I was brought forth;
> before he had made the earth with its fields,
> or the very first dust of the world.
> When he established the heavens I was there,
> when he drew a circle on the face of the deep,
> when he made firm the skies above,
> when he established the springs of the deep,
> when he assigned to the sea its limit,
> so that the waters might not transgress his command,
> when he marked out the foundations of the earth,
> then I was beside him, like a master workman.

Apart from the verse in question (8:24), the passage seems to be chiefly about what God did on Day 3. Establishing the heavens and making firm the skies best fits with Day 2, when God made the firmament. The remainder is about the work of separating out the land from the seas, forming the land and making it habitable. Clearly these verses do not represent a chronological sequence. Note the parallelism linking nouns within or between the verses:

deep	fountains abounding with water
mountains	hills
earth	dust
heavens	skies
circle on the face of the deep	springs of the deep
sea	waters

In every case not involving fountains *(mayenot)* or springs *(ayenot)* the pairs are near synonyms, with each second noun or noun-phrase denoting a part or aspect of the first. (The second term is 'hyponymous' to the first.) Accordingly, the natural reading is to suppose that the other pairs also involve near synonyms. The 'fountains abounding with water' are part of the 'deep' and the 'springs of the deep' are a part or aspect of the terrestrial circle (*i.e.* continent)[3] which was inscribed on the surface of the deep; the fountains/springs were features of the land, fed by the deep beneath the land. Likewise, Bryan Beyer in NIDOTTE refers the springs in Proverbs 8:28 to subterranean waters.

Not even Job 38:16 gives grounds for supposing that suboceanic springs could be signified by *mayan*. Along with its context the verse reads:

> Have you entered into the springs of the sea,
> or walked in the recesses of the deep?
> Have the gates of death been revealed to you,
> or have you seen the gates of deep darkness?
> Have you comprehended the expanse of the earth?
> Declare, if you know all this.

The word for ‘springs’ here is *nibke* and does not occur elsewhere in the Bible. Nonetheless, the phrase ‘*nibke* of the sea’ clearly evokes the ‘springs of the deep’ of Proverbs 8:28 and ‘fountains of the deep’ of Genesis 7:11, and thus (as Fouts and Wise recognise) is likely to be synonymous. The clue to their location may be found in the immediately following verses, which speak of the gates of Sheol within or beneath the earth and then refer to the expanse of the earth itself. The entire chapter comprises a series of thematically homogeneous stanzas:

Verses	Subject matter
1–3	Intervention by God
4–7	Structure of the earth (dry land)
8–11	Enclosure of the sea
12–15	Succession of day and night
16–18	Places underneath the earth
19–21	Places of light and darkness
22–24	Snow, hail, lightning(?) and wind
25–28	Rain and thunder
29–30	Ice and frost
31–33	Constellations
34–38	Clouds
39–40	The lions
41	The raven

Since vv. 17–18 refer to the depths of the earth, it seems logical to take v. 16 as referring to the depths of the earth, and to interpret ‘the springs of the sea’, therefore, as terrestrial springs. Every determinable use of the related terms *mayan* and *ayin* accords with this understanding. So do verses elsewhere which associate the underworld with water (Job 26:5f, Psalm 69:15, 88:6, Ezekiel 31:15).

Fouts and Wise’s sole evidence adduced for the idea that *mayan* could signify an oceanic spring is Proverbs 8:24 and Job 38:16, and these occurrences, upon analysis, do not support the claim. Their conclusion that ‘according to Scripture … springs (including *ma’yan*) can be either terrestrial or oceanic’ is unwarranted.

The fountains of the great deep

Although the authors analyse the phrase ‘the great deep’ *(tehom rabba)* as if it might signify something different from just ‘the deep’, the two phrases are used interchangeably (Genesis 7:11, 8:2). No especial significance can therefore be attached to the adjective; it simply brings out a quality which is already inherent in the noun, *i.e.* the deep’s immensity. (But compare the very similar phrase ‘many waters’, *mayim rabbim*, which is rich with connotations (May, 1995).)

The deep seems to have been conceived as a virtually continuous body of water surrounding and underlying the land, and fountains (*i.e.* springs) in the Old Testament are invariably terrestrial fountains and springs. The deep was the source of the rivers in Eden before the Flood (*cf.* Ezekiel 31:4,15) and in Mesopotamia after the Flood (Isaiah 44:27). The earth was therefore said to be established upon the rivers. The deep was also, consequently, the source of the earth’s springs (Genesis 2:5f, Deuteronomy 8:7, Psalm 78:15). In the only place where the phrase ‘fountains of the deep’ appears outside Genesis, namely Proverbs 8:28 (although *ayin* is the word used for ‘fountain’), the context indicates that they were an essential feature of the original creation, along with mountains, hills and fields. The earth was underlain by ‘storehouses’ of waters (Psalm 33:7) in order that it might be irrigated by these ‘deeps’ (Proverbs 3:20) and blessed by them (*cf.* Genesis 49:25, Deuteronomy 33:13). There is no evidence in Scripture that ‘the fountains of the deep’ signified, even in a secondary way, springs under the oceans.

In his comprehensive discussion of the point Tsumura (1989) concludes that the word *ed* in Genesis 2:6 is an Akkadian loan-word referring to water which rises *to*, rather than *from*, the surface. A suffusing moisture went up from the earth *(erets)* to water the entire face of the ground *(adamah)*. Similarly, in the Atra-hasis epic (the oldest surviving version of the Babylonian flood tradition), the god Enlil commands, some time before he sends waters to engulf the earth:

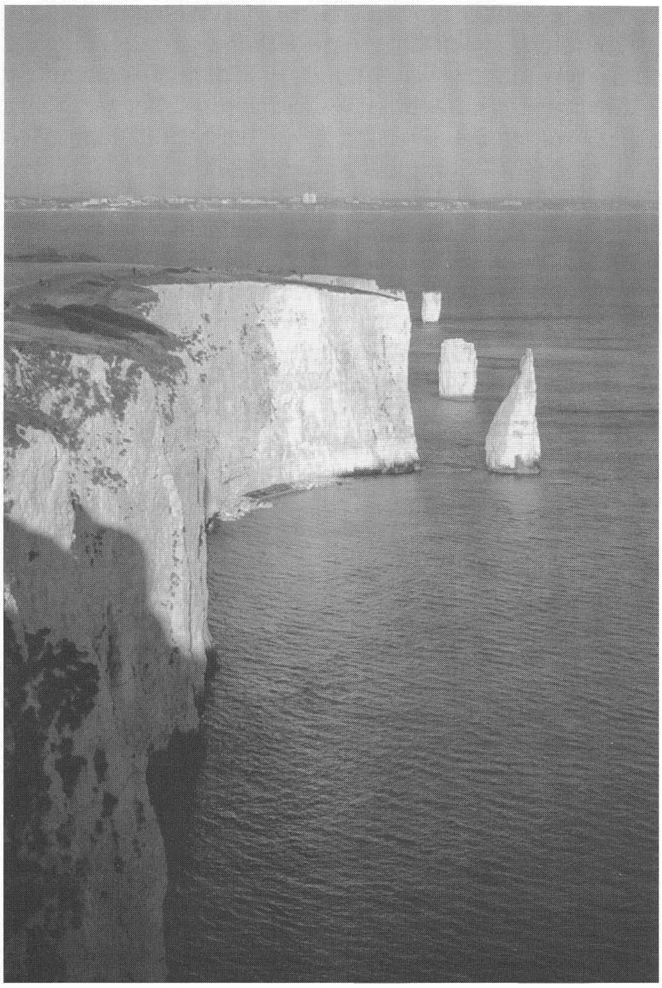
> Cut off supplies for the peoples
> Let there be a scarcity of plant-life to satisfy their hunger.
> Adad [the rain god] should withhold his rain,
> And below, the flood should not come up from the abyss.

And so it came to pass.

> Above […]
> Below, the flood did not [rise] from the abyss.
> The womb of the earth did not bear,
> Vegetation did not sprout. […]
>
> (Lambert and Millard, 1969)

While these verses may have little value as history, they do illustrate how the pairing of rain from above and plant-watering moisture from below was a commonplace in the Ancient Near East (Weinfeld, 1978).

Thus the springs which erupted at the beginning of the Flood were springs which watered the land. The picture is of ‘water gushing forth uncontrollably from wells and springs which draw from a great subterranean ocean’ (Wenham, 1987). There is ‘not the slightest indication of an inundation caused by the rising of the rivers or the swelling of the sea’ (Heidel, 1949). Likewise there is nowhere in Scripture the slightest indication that there existed a body of water under the ocean floor which supplied, via springs, the waters which were above the ocean floor. Even if the oceans and earth had been originally so structured, it is not obvious how the breaking up of such springs could have initiated an inundation of the continent. The two bodies of water above and beneath the ocean floor would merely have intermingled, with little net change in sea level.



Harry's Rocks, Dorset. Although coastlines change and low-lying areas are sometimes inundated, there will never be another global inundation. Could the present earth be different from the earth that was flooded in the days of Noah?

The earth that was destroyed

The Hebrew word *erets* ('earth') has essentially three meanings: first, the whole planet, distinct from the heavens, as (for example) in Genesis 1:1, Job 26:7, Psalm 135:6f, 148:7, Haggai 2:6b; second, the continent, the dry land distinct from the seas, as in Genesis 1:10, Job 38:18, Psalm 24:1f, Proverbs 3:19, Isaiah 44:24; and third, a land or country, as in Genesis 2:11, 4:16, and 10:11.[4] When God calls the dry land 'earth' in Genesis 1:10, the word has a different sense from the sense in Genesis 1:1.

Scripture does not explicitly say whether the dry land consisted, as now, of more than one continent. Proverbs 8:27 might be taken to imply a single landmass, and it would certainly have been easier for Noah if he had not had to cross seas or oceans to collect examples of every kind of animal. Conversely, if man's division into 'languages, lands and nations' after the Flood is representative of the diversification of all animals, the genetic and geographic segregation which brought about this diversification is likely to have been primarily a post-Flood development.[5]

Apart from these considerations, Genesis says that the dry land emerged at Creation on the same day as the waters were gathered 'into one place'. This phrase is difficult to reconcile with present geography. Wenham (1987) interprets it as indicating a dry land which encloses seas geographically within it. However, this does not explain why 'seas' is plural when 'place' is singular. Although one may argue that there is no significance in the plural on the grounds that 'sea' and 'seas' are interchangeable (*e.g.* Jeremiah 15:8 and 33·22), singular and plural are demonstrably interchangeable only when the plural is used poetically—just as either singular and plural can be used in poetic contexts in English. In other passages the seas seem to be visualised as geographically enclosing the land (Proverbs 8:27, Isaiah 40:22).

Perhaps it would make better sense to understand the waters being gathered from within rather than from around the earth. Thus Job 38:8 speaks about the sea bursting forth from the womb, as if from the interior of the earth, just as the atmosphere was formed by a vertical separation. With the gathering of the waters into one place on Day 3 the ocean floors were formed, as well as the dry land. The seas were gathered 'as in a jar' (Psalm 33:7). Before that point there were no seas, only waters—formless, undifferentiated and uncontained. Thereafter the waters were 'in' the seas (Genesis 1:22), and dry land appeared as a result of the waters being gathered. The earth came into being 'out of water and through water' (2 Peter 3:5). The seas were a plurality around the land in the same way as one speaks of the Timor Sea, the Arafura Sea and the Tasman Sea around the continent of Australia.

The six days of Creation climaxed with the creation of man, the one creature to be made in the image of the Creator. All that had been made had been made for man. To him was given dominion over every creature that inhabited the earth and dominion over the earth itself (Genesis 1:28). Thus when wickedness had spread so far that all flesh had become corrupt, God determined to destroy not only man but everything which had been polluted through him, including the earth.

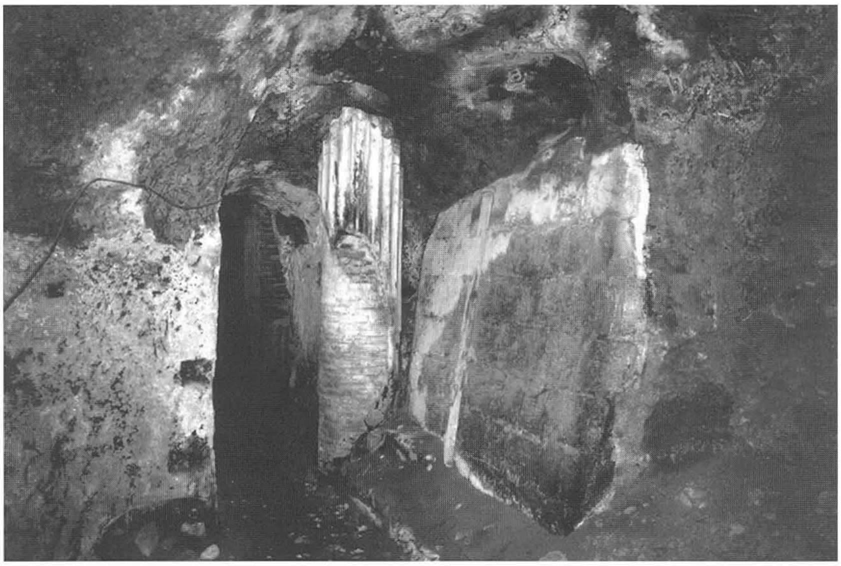
> The earth was corrupt before God, and the earth was filled with violence. God saw the earth, and behold it was corrupt; for all flesh had corrupted its way upon the earth. And God said to Noah, 'The end of all flesh has come before me; for through them the earth is filled with violence; and behold, I will destroy them with the earth.' (Genesis 6:11–13)

The text insists upon the corruption of all things under man, for the logic of this situation was that God would do away with polluter and polluted alike: the dry land and every creature that moved on the dry land together. Through the same waters out of which the earth had been made,

> the then world, having been deluged with water, perished. But the present heavens and the earth by his word are stored up for fire. ... (2 Peter 3:6)

Every creature on the earth was blotted out from the earth in the course of the earth itself perishing. We live now on a different earth from that which perished.

A final point to consider is whether 'earth' here means the whole earth or only its surface. In principle, the image conveyed by the word could be the dry land in its lateral rather than vertical extent. However, there are several



Wall and pillar on the north-west side of the House of Argus, Herculaneum, still buried under volcanic mud from the Vesuvius eruption. Why do we find no similar traces of cities from before the Flood?

reasons why more probably its entire thickness is signified.

1. Where *erets* means dry land distinct from seas, it generally denotes the whole land (see examples above). This is particularly clear where there is an explicit contrast with seas or heavens, which one also does not conceive of in two dimensions.
2. Genesis 6:13 and 9:11 refer to the destruction simply of the earth, not (as in Gen 6:7 and 7:23) of the 'face of the earth', or the 'face of the ground'. Similarly, while the force of the Hebrew word *(shachath)* can vary from 'mar' or 'corrupt' to 'destroy utterly', depending on context, the use of the same word in 6:17 and 9:15, where it is equivalent to *machah* ('blot out'), suggests that complete destruction is intended.
3. The mention of the great deep from which the surface springs were supplied induces one to think of the earth three-dimensionally. The explosive release of its waters suggests that they destroyed the earth from the bottom up, shattering its entire fabric.
4. Since the oldest parts of the ocean crust date to the Jurassic, it is evident that the pre-Flood ocean floor has totally disappeared. Indeed, extensive plate-tectonic movements seem to have occurred from as early as the Precambrian, so that the ocean crust may have been replaced more than once. If this is true of the entire thickness of the ocean crust after the Flood, it becomes somewhat inconsistent to suppose that only the surface of the earth was destroyed during the Flood, when the earth was the express object of destruction.
5. There are scriptural grounds for associating the opening of the windows of heaven with bombardment by comets or asteroids, on the analogy of what is prophesied for the days before both the heavens and the earth are renewed (Isaiah 24:18f, 65:17, Haggai 2:6, Revelation 6:12–14). The Moon testifies to extremely intense bombardment at the beginning of geological history (4·6–3·9 Ga radiometric time). The corresponding period on Earth has no rock record, presumably because whatever land existed at that time was destroyed.

None of these arguments (which involve both biblical and non-biblical considerations) is necessarily conclusive. However, as there are only two possibilities—partial or total destruction—their combined weight surely puts the balance of probability in favour of the latter.

Implications for geological Flood models

If the analysis presented in this paper is correct, there are important geological consequences:

- The pre-Flood earth was inundated through the eruption of vast reservoirs of water under the earth, not through a marine transgression (such as, in some places, ushered in the Cambrian).
- Since all animals living on the land were blotted out, fossils of such animals, which occur in rocks continuously from the Middle Palaeozoic onwards, must belong to animals that were recolonising the land after the Flood (probably long after the Flood, given the statistical unlikelihood of an early coloniser appearing in the fossil record).
- If the pre-Flood earth was totally destroyed, the boundary which separates the pre-Flood world from strata laid down in the Flood must lie beneath the present crust, and Creation Week rocks no longer exist.

These findings (which are not, of course, the only biblical criteria to be satisfied) can be used to test geological models of the Flood. Two may be selected as representative: the Catastrophic Plate Tectonics model of Steve Austin *et al.* (1994) and the 'European' model of Joachim Scheven and others (Scheven, 1988; Scheven, 1990; Robinson, 1996; Garton, 1996; Garner, 1996a; Garner, 1996b; Tyler, 1996).

The Catastrophic Plate Tectonics model conflicts with the biblical record in all three respects. (1) It postulates that the Flood was caused by the floor of the oceans breaking up and water spilling onto the land in a marine transgression. (2) It assigns the Palaeozoic and Mesozoic to the Flood, despite all palæontological evidence to the contrary. And (3) it identifies a large part, if not most, of the geological record as either originally created rock or sediments deposited in the period between Creation and Flood.

Thus, instead of terrestrial springs pouring out water, the model interprets the fountains of the great deep as 'a linear geyser of superheated gases along the whole length of spreading centres', a phenomenon of the seas rather than the land, and not part of the original creation at all. Instead of all terrestrial animals being blotted out from the earth, it has them outcropping on the face of the ground for modern-day geologists to study. And instead of the total destruction and replacement of the land during the Flood, it postulates, through catastrophic plate tectonics, the total destruction and replacement of the sea. Biblically, the model cannot be saved merely by acknowledging that springs erupted on the land at the same time as the ocean bubbled up over vast gashes of erupting lava.

The European model is already a response to the perception that ICR diluvialism contradicts Scripture. Consequently it avoids some of its shortcomings. It recognises, for example, that the eruption of the fountains of the deep was a releasing of subterranean water, and that fossils of terrestrial life postdate the Flood. On the other hand, it pays no regard to the testimony that the earth itself was destroyed in the Flood and does not satisfy other biblical constraints. For example, it lacks geological support for the idea that in the Silurian (or at any other time in the Palaeozoic) the whole earth was under water. It is evident that a model which, in the main, recognises what Genesis says but not what the geological record says cannot claim to be an explanation of the geological record. Such obstinate features as Precambrian and Phanerozoic stromatolites, Carboniferous coals, biogenic carbonates, in-place reefs and encrusted hardgrounds, evolutionary lineages, and the geographic distribution and chronostratigraphic order of fossils contradict both models.

The biblical record matters, of course, because it is true. The failure of current geological models to satisfy its criteria does not entail that the biblical record itself is wanting—though that, amongst doubters, is the impression given, and, amongst supporters of the models, is the fear which inhibits any re-think. The better conclusion is that they fail scientifically precisely because they fail biblically. Scripture judges all, prophets and people alike. If its hammer destroys our long-held theories, we must let the hammer do its work, and seek an explanation which is more consistent with the scriptural and physical evidences. The results of this study suggest that this is needed. Flood geology needs to be reborn, not merely—from its discredited residue in the 19th century—resuscitated and reclothed.

ACKNOWLEDGEMENTS

I am grateful to Richard Johnston for his constructive comments on an earlier version of this paper.

Notes

1. There is no explicit mention of waters in Deuteronomy 32:22
2. The Septuagint translates *tehom* as *abussos*, *i.e.* abyss (*lit.* the place that is bottomless; the word is not related to *Apsu*).
3. *Cf.* Isaiah 40:22. In Job 26:10, by contrast, the circle described on the face of the waters is the boundary between the hemisphere of light and hemisphere of darkness. Seely (1997) illogically interprets the 'circle on the face of the deep' in Proverbs 8:27 as the seas around the earth.
4. It might be argued that Genesis 11:1 ('the whole earth had one language and words') illustrates a further meaning, namely the earth's inhabitants; however, this is more properly analysed as an example of the second meaning used metonymously.
5. It is doubtful whether Genesis 10:25 has anything to do with the earth's division into continents. See: Fouts, D. M. (1998). *Peleg in Gen 10:25*. Journal of the Evangelical Theological Society, 41:17–21.

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Review Article

Secure foundations?

Philip Duce

ACCORDING to the cover text, *Science, Life and Christian Belief* is 'an overview of the background, framework of understanding and current state of the sciences. Its wide-ranging picture reveals the major role of Christian belief in shaping and nurturing the enterprise of science'.

The authors are distinguished scientists. Malcolm Jeeves is Honorary Research Professor at the University of St. Andrews School of Psychology. He was awarded a CBE (1992) for services to psychology and is President of the Royal Society of Edinburgh. R. J. ('Sam') Berry is an ecological geneticist and Professor of Genetics at University College, London. He is a Fellow of the Royal Society of Edinburgh, and received the Templeton UK Individual Award for progress in religion in 1996 for his 'sustained advocacy of the Christian faith in the world of science'.

This book is a revised, updated and expanded edition of *The Scientific Enterprise and the Christian Faith*, written by Jeeves in 1969 (based on a conference held in 1965). It is a substantial contribution to the challenging discipline of 'science and theology', offering a comprehensive survey of the sciences and their interaction with the Bible and Christian belief, from an evangelical perspective. The discussion is detailed, with extensive end-notes, and inevitably reflects the authors' strengths in biology and psychology, rather than the physical sciences. A notable omission is a chapter on geology. Each subject requires a searching review in its own right—which is not the purpose of this article! Rather, I will interact with a selection of general statements in the book, which give rise to some foundational issues and questions[1]: How should science interact with the Bible? What is the overall assessment of the scientific enterprise? What characterizes the wider framework of presuppositions? How does this framework look in the end-of-century cultural context?

The Bible and Science

Jeeves and Berry write 'not as philosophers, historians of science or theologians, but as working scientists' (p.11), who are 'enthusiastic about their science and what it has to offer humankind, and who seek to live as committed Christians' (p.12). So, for all their distinction and seniority as scientists, they are intelligent lay theologians and Bible users.

These authors

> fully accept the revelation of God in his written and living Word; the problem in every generation is to interpret this revelation in a consistent way. This has sent us back repeatedly to check to the best of our understanding what the Bible *actually* says, as distinct from how it has been *conventionally interpreted* (p.12, their italics).

Science, Life and Christian Belief, by M. Jeeves and R. J. Berry is published by Apollos, Leicester (1998)

Immediately, there are problems. 'Conventional interpretation' is a strange phrase: I take it to mean conservative interpretation, or the interpretative legacy of church tradition. As it stands, the statement is naive, unrealistic and, it must be said, somewhat arrogant. It expresses a tendentious, and arguably false, dichotomy. 'Understanding what the Bible actually says' involves interpretation and cannot avoid hermeneutical and exegetical issues; 'conventional interpretation' has not necessarily overridden or ignored such issues. Indeed, the intention of the most responsible 'conventional' or 'traditional' interpretation has been precisely to understand what the Bible actually says and means. Affirmation of the perspicuity or clarity of Scripture in no way precludes the need for interpretation.

The value of the church's exegetical tradition—used in submission to Scripture itself—should not be underestimated, and the right of individual interpretation should be balanced by the corporate wisdom, counsel and judgment of the church (*cf.* Silva, 1987, pp.77–97). Furthermore, the perspicuity of Scripture should be distinguished from some kind of context-free 'plainness' or 'obviousness' of meaning, and implies that understanding is possible, not that it is always easy (*cf.* 2 Peter 3:16).

Jeeves and Berry 'take the biblical teaching seriously' (p.13) and acknowledge that the Bible must be permitted to set its own agenda (p.137). However, they also claim that 'our understanding of the Bible has to be continually re-examined in the light of secular knowledge, since this affects our background understanding of the world' (p.243). This statement is problematic and raises more questions. What exactly does 'secular knowledge' mean, or imply? Should our understanding of the Bible be subject to it? (See below.)

Furthermore, we are told that 'internally consistent biblical exegesis which neglected other ways of learning about God's work' has led to 'gaps between science and faith', and they have given examples of where this dubious claim supposedly applies: belief in a geocentric universe (Pope Urban VIII *vs.* Galileo); creationist models of creation; dualistic separation of body and soul (p.243). This is a highly tendentious comment on what are actually complex cases.

For 'accepting and using different streams of information' from the Bible and science, Jeeves and Berry use the analogy of a model of the way the human visual system works:

> The common inputs from the outside world are subject to different transformation and proceed through distinguishable channels which are subsequently recombined in the processing systems of the brain. To operate at optimum efficiency, we have to use all incoming information transformed and filtered in ways which reflect the different functions of the incoming streams. (p.245)

Also:

> In every generation, new light bursts forth from the study of God's written Word. We are indebted to the biblical scholars and theologians who help us in this venture...
>
> As we continue to explore our wider understanding and our changing interpretations of the implications of scientific discoveries, so our understanding and interpretation of the Bible may change in the light of such new knowledge. It may, for example, warn us off what a particular passage cannot mean as we compare scripture with scripture with an open mind. (p.251)

There are correct affirmations here, but the overall presentation is slippery, and again sets hermeneutical alarm bells ringing. Rearrangement and different emphases are needed for a basic, properly evangelical, model for relating science and the Bible. I suggest the following principles:

This article is a modified version of a lecture given at the UK L'Abri Fellowship, Greatham, on 13th August, 1999.

1. The fundamental rule of hermeneutics is that Scripture is its own interpreter. As the Westminster Confession (1, IX) puts it:

   > The infallible rule of interpretation of Scripture is the Scripture itself; and therefore, when there is a question about the true and full sense of any Scripture (which is not manifold, but one), it must be searched and known by other places that speak more clearly.

   Or the 1982 Chicago Statement on Biblical Hermeneutics (Article 17):

   > We affirm the unity, harmony, and consistency of Scripture and declare that it is its own best interpreter. We deny that Scripture maybe interpreted in such a way as to suggest that one passage corrects or militates against another. We deny that later writers of Scripture misinterpreted earlier passages of Scripture when quoting from or referring to them.

   This fundamental principle rests on the prior confidence in the Bible as the inspired Word of God, the one Author who unites the work of the diverse human authors. The Bible is coherent and consistent. These are aspects of an evangelical doctrine of Scripture, but the interpretative principle is not really affirmed clearly by Jeeves and Berry.

2. This not to deny that scientific understanding of God's creation may, in principle, assist in the interpretation of God's Word (as Jeeves and Berry affirm). To quote James Montgomery Boice [summarizing CSBH Articles 19–21]:

   > Scripture interprets scientific knowledge by relating it to the revealed purpose and work of God, thus establishing an ultimate context for the study and reform of scientific ideas. It is not for scientific theories to dictate what Scripture may or may not say, although extra-biblical information will sometimes helpfully expose a misinterpretation of Scripture ... [and] may help toward attaining a more precise exegesis. (Boice, 1997, p.176)

   Note that scientific ideas should be utilized—and perhaps 'reformed', or subjected to correction—within a biblical framework. There may be naturalistic presuppositions or other ideological influences which are incompatible with general or specific biblical teaching.

3. However, while Jeeves and Berry's concern to 'take into account both books of God' should be affirmed, there is an important proviso. To quote John Frame:

   > A scientific discovery... may lead me to change my interpretation of Scripture at some point, though it cannot in itself *dictate* such a change. But if, after reflection, I determine that my original interpretation of Scripture was correct and that still conflicts with the apparent results of science, then I must follow Scripture. (Frame, 1987, p.316; original italics.)

It is noteworthy that Berry is 'horrified' by this statement, claiming that it 'opens all sorts of inconsistencies' (Berry, 1999). However, it is difficult to imagine what other approach responsible evangelical exegetes might adopt.

Jeeves and Berry confidently allow the Bible to be reinterpreted in the light of science, but do not appear to allow the converse—where biblical teaching calls into question ('mainstream') scientific claims. This need not imply some kind of 'fundamentalism' which 'makes the Bible teach science'.

Furthermore, their position could be taken to imply that we have been unable to interpret Scripture correctly until, say, the 19th century (with the discovery of fossil evidence and development of evolutionary theory).

Some comments by Blocher are pertinent when the sciences are allowed undue influence in biblical interpretation:

> If the Bible is the Word of God, no authority, even one at the apex of the scientific world, may impose his authority on the Bible in order to dictate how it is to be understood, even with the best of intentions...Even if the 'facts' invoked are of God—for scientific opinions grasp these facts in a fallible manner and cannot approach on the authority of God *speaking himself.* (Blocher, 1984, p.25; original italics)

The fact that the doctrine of biblical authority is hermeneutically intertwined with exegesis (Duce, 1999, p.40) does not invalidate this point.

Complementarity

The 'human visual system' analogy illustrates a statement Jeeves and Berry make with regard to what they assert to be 'the core of the book':

> the need to appreciate the complementarity of scientific (or causal) and formal explanations, which may involve divine activity. The latter can be approached only by faith (p.131).

Jeeves and Berry reiterate Donald MacKay's definition of complementarity from 25, or even 45, years ago (pp.80–82). Its meaning in this context is, essentially, that science and theology or the Bible are concerned with the *same* phenomena, but address *different* questions through different methods and languages, for different purposes.

Jeeves and Berry acknowledge that complementarity is open to abuse and misunderstanding (quoting MacKay from 1953) (pp.80–82), but ignore critiques such as those collated by the present writer (Duce, 1999, pp.63–69).

So, in general:

> The scientific description of events is complementary and not contradictory to the Bible or to teleological explanations. (p.115)

For example, with respect to human nature:

> Faced with ... pairs of complementary ideas, framed either psychologically or theologically, we are like someone stranded in a deep well with the two ends of a rope dangling down. If we grab either one alone we fall even deeper. Only when we hold both ropes can we climb out, because at the top, often beyond where we can see, they come together around a pulley. Grabbing only the rope of rationality or irrationality, of self-serving pride or of self-esteem, of 'attitudes first' or of 'behaviour first', of personal or of situational causation, plunges us to the bottom of a well. So instead we have to grab both ropes, perhaps without yet fully understanding how they relate. In doing so, we may be comforted that in both science and religion a confused acceptance of complementary principles is sometimes more honest than an over-simplified theory that ignores half the evidence. (p.216–217)

Or evolution:

> There is a credible scientific account of chemical, geological and biological evolution which complements the religious account of creation. The Bible tells us something of the meaning of the world in which we live (that is, it deals with 'why' questions); science deals with the mechanisms by which evolution occurred, which are not described in the Bible (that is, science answers 'how' questions). (p.249)

The latter statement in particular has become a tired, and tiresome, cliché.

In response, essentially it is *much* better to say that the sciences and theology or the Bible each address their own kinds of 'how?' or 'why?' (or 'what?', 'who?', 'when?') questions, and make their own *truth claims*, which in general may be complementary in some sense—but which, in some cases, may be independent, or may interact at the *same* level.

Furthermore, my book has a whole chapter dealing with conflict between science and the Bible (Duce, 1999, pp. 79–100). Despite heeding MacKay's warning, Jeeves and Berry seem to look for resolution in complementarity, even if it is 'confused acceptance' of the concept.

Natural theology

In the light of the quotation at the beginning of the last section, the question arises: what about natural theology? Can anything of God be known from study of the natural world? This issue is little discussed, as it is correctly perceived to be 'disputed among theologians' (p.251).

Jeeves and Berry acknowledge that the created order 'must bear the marks of the Creator's character, however veiled'. They appreciate the 'revised natural theology' of, for example, John Polkinghorne: science discloses the intelligibility of the universe, which points to a 'cosmic architect or 'great mathematician', but not to a full knowledge of the God of Christian theism. For the latter, special revelation is needed. This is seen to be consistent with, for example, Psalm 19:1, Acts 17:22–31, and Romans 1:19ff with the warning about putting trust in rebellious man's 'wisdom' (pp.97–98). This overall position echoes Calvin [Institutes I], but he is not mentioned in this context.

We now turn to a closer look at theological perspectives on the scientific enterprise and examine where Jeeves and Berry stand on this issue.

Theological perspectives on science

The basic validity of the scientific enterprise may be affirmed as an aspect of common grace. Calvin comments that those who reject every fruit of pagan learning offend the Holy Spirit who has bestowed such gifts on the heathen. He goes on to say:

> If the Lord has willed that we be helped in physics, dialectic, mathematics and other like disciplines, by the work and ministry of the ungodly, let us use this assistance. For if we neglect God's gift freely offered in these arts, we ought to suffer just punishment for our sloths. (Institutes II.ii·15,16)

So, to quote Donald Macleod:

> The achievements of unbelieving scientists reflect the goodness of God not only towards the scientists on whom He conferred splendid endowments but also towards the race which enjoys the benefits of their discoveries. (Macleod, 1990, p.120)

However, 'the limitations of common grace ... have ... led some Christian thinkers to distinguish radically between regenerate and unregenerate science' (Macleod, 1990, p.138). For example, in the context of the increasing secularization of European society in the nineteenth century, Abraham Kuyper saw a fundamental antithesis between two competing world-views: Calvinism (grounded on the principle of God's sovereignty) and Enlightenment (grounded on unbelief, on humanistic and naturalistic principles), in the realm of science, this antithesis implied a sharp division between those who believed the cosmos to be in an abnormal (fallen) state and those who believed it to be normal (unfallen) (Heslam, 1999).

As Macleod points out, the influence of Kuyper's regenerate–unregenerate distinction actually varies enormously from situation to situation. As Kuyper himself acknowledged, there is a very broad realm of investigation in which the difference exerts no influence, because regeneration involves no change in the senses or the conception of visible things. For example, in empirical observation, or formal logical thought, the influence of regeneration is virtually nil. Historically there has been significant overlap between the influence of the two factors, and the difference between them is not absolute (Macleod, 1990, pp.138–139). However:

> The problems increase when *inferences* have to be made, especially if these inferences involve social, moral and religious judgments, as they do in history, psychology and sociology. They are most acute in areas of conflict between science and revelation, such as anthropology, geology and biology: here there is a grave risk of suppression and distortion under the influence of *a priori* religious and philosophical considerations. (Macleod, 1990, p.138).

Jeeves and Berry have one small section, of less than a page, where they 'take formal account of presuppositions'. They acknowledge Kuyper and his followers (Cornelius Van Til, Herman Dooyeweerd and Francis Schaeffer), who 'strongly influenced twentieth century theology'. However,

> they should not be allowed to obscure the traditional insistence that the world and reality can be understood by all (Romans 1:19–20), that although interpretations can be distorted by presuppositions, the underlying phenomena are real and recordable by any scrupulous observer irrespective of his or her religious beliefs. Calvin commented that those who reject every fruit of pagan learning offend the Holy Spirit who has bestowed such gifts on the heathen (*Institutes* II.ii·15). (pp.242–243)

Again, there are correct affirmations, but cast in a slippery form—and some dubious exegesis. The 'formal' acknowledgement of the influence of presuppositions is just that—it is not carried any further, but simply countered by assertion of the Calvin reference. This is an insufficient response to the issue raised by the Kuyperian perspective.

Despite the acknowledgement that interpretation can be distorted by presuppositions, the confident assertion that reality is 'recordable' by 'scrupulous observers' seems to imply 'naive realism', in which there is a direct relation between the external world and human perception. It is enough to observe the phenomena and to describe them correctly; there is no gap between appearance and 'reality'. It is doubtful whether, as practising scientists, Jeeves and Berry really mean to say this.

With respect to exegesis, the bracketed reference to Romans 1:19–20 appears to imply that 'common grace enables the unregenerate to 'see clearly' in the realm of science'—but these verses are primarily concerned with general revelation (there is a God; there is a Creator) (Watts, 1982). The conclusion with respect to natural science may—or may not—be a legitimate implication, but this is still a tendentious handling of Scripture. [Indeed, this illustrates a typical feature of the book: statements or claims are made, with Scripture references in brackets, implying that the former are 'scriptural'. Close examination often begs exegetical questions.]

For Jeeves and Berry, phenomena are 'real and recordable' irrespective of background beliefs, but interpretations can be 'distorted' by such beliefs. Even if the regenerate-unregenerate distinction should not be pressed too far, this issue is not explored further—no doubt because these authors espouse *methodological naturalism.*

Methodological naturalism

To understand this, we start with a Christian *world-view*, which Jeeves and Berry characterize as follows (pp.62–64):

> its central focus is God whom we know in Christ: the triune God as revealed in the Scriptures as our Creator, Redeemer and Comforter; it incorporates a specifically theistic doctrine of Creation: there is one God who is the Creator and moment-by-moment upholder and sustainer of everything, and who is free to choose the behaviour of the created order; it differs from metaphysical or philosophical naturalism, where the physical universe is all there is: self-existent, self-governing, no transcendent deity.

An associated world-*picture* is a set of concepts concerned with the contents and behaviour of the *physical world.* Metaphysical and methodological naturalism are distinguished. Methodological naturalism

> is a scientific strategy which can commend strong support. We do not continually have to reassert God's existence, because belief in His existence is already part of the historic foundations of the modern natural sciences. Methodological naturalism should be correctly understood as a useful approach to scientific work ... [W]e need to recognize that natural science is constrained by methodological naturalism and does not pretend to produce answers to the ultimate questions.'The question 'Why?' is not to be answered from within science, except to say that we have gone as far as our methods of natural science have taken us at this time. Christians should be comfortable with methodological naturalism in the natural

> sciences simply because God himself is sovereign over all of life. (pp.63–64)

Jeeves and Berry quote Howard Van Till (a US counterpart):

> The purpose of empirical research is to discover what the physical world, as an intelligible system, is really like, not to verify its conformity to our prejudices. And the aim of scientific theorizing is to describe the actual character of the universe, not to force its compliance with our preconceived requirements... Science held hostage to any ideology or belief system, whether naturalistic or theistic, can no longer function effectively to gain knowledge of the physical universe. (p.69)

The rather tendentious language is presumably used to resist both philosophical naturalism and 'creation science'.

Jeeves and Berry do acknowledge that 'there are no such things as uninterpreted facts' (p.52), but assert that 'sound' science can function on the basis of its own criteria, such as predictive accuracy, internal coherence, external consistency, unifying power, simplicity (p.69).

In response we may affirm this, but here there is still a tendency towards an over-confident belief in the neutral objectivity of human critical analysis (a legacy of the Enlightenment). Discovery and theorizing *are* influenced by background beliefs and ideology. Indeed, developments in the philosophy of science over the past 40 years have established that there is no ultimately value-free science. So, in the final section, we need to consider briefly what Jeeves and Berry say about the philosophy of science.

Philosophy of Science

Three approaches are surveyed: in particular, logical positivism, falsificationism (Karl Popper) and Kuhnianism (Thomas Kuhn). These are all rightly found to be unsatisfactory (pp.49–62).

Jeeves and Berry rightly state that the success of science cannot be accounted for by a social construction of reality, but that this success comes from discoveries about the nature of reality. They rightly conclude that 'only a realist philosophy of science will be productive. In other words, the scientific enterprise presupposes that its efforts approximate to an accurate account of truth, of the way the world is' (p.61). However, Jeeves and Berry's realism seems to be articulated more in 'naïve' terms (*cf.* earlier) than 'critical'.

Critical realism is 'a way of describing the process of 'knowing' that acknowledges the *reality of the thing known, as something other than the knower* (hence 'realism'), while also fully acknowledging that the only access we have to this reality lies along the spiralling path of *appropriate dialogue or conversation between the knower and the thing known* (hence 'critical')' (Wright, 1992, p.35; original italics). Within such dialogue, which can involve models or analogies, perception of reality is indirect.

Critical realist philosophy is denied, of course, by postmodern hermeneutical non-realism. The discussion in *Science, Life and Christian Belief* fleetingly touches on postmodernity, with respect to those who argue that 'scientific knowledge is a cultural construct' (p.61). Earlier, Jeeves and Berry claim that the 'anti-realism' which sees truth and reality as a construct of language, rather than as something to be discovered, has 'spawned the 'postmodernity' debate, with its assumptions that all beliefs are relative' (p.52). This is a very superficial handling of a highly relevant and important issue. Postmodernity is not *synonymous* with relativism, and not everthing in the 'postmodern' mindset should be rejected.

Recall the earlier quote:

> the need to appreciate the complementarity of scientific (or causal) and formal explanations, which may involve divine activity. The latter can be approached only by faith. (p.131)

Also, for these authors

> An understanding and acceptance of modern science does not—and cannot—prove anything about the existence and activity of God. (p.248)

Such statements reveal a dualistic undercurrent. This is also borne out by the occasional use of the phrase 'science and faith' (*cf.* pp.12, 26, 81, 243, 244). Perhaps this is just a convenient label, but it is unsatisfactory, nevertheless. Simply put, science has a 'faith' element (presuppositions, trust, epistemology); faith has a 'scientific' element (weighing of evidence; historical basis). The 'science and faith' pairing can so easily tend towards compartmentalization, ultimately leading, down the slippery slope, to the extreme polarization of 'scientism and fideism'. I suggest that, for all their efforts, Jeeves and Berry have not always escaped this tendency. The essential point here is that such a dualistic tendency is a problem which needs to be resolved in the context of postmodernity, with the breakdown of the Enlightenment project.[2]

Summary

For all its merits, there are cracks in the foundations of Jeeves and Berry's impressive building. These arise from the treatment (or lack of treatment) of deeper presuppositions; the reiteration of complementarity, with a somewhat dualistic undercurrent; the general confidence in 'mainstream' scientific consensuses; the lack of engagement with issues arising in the context of post-modernity.

All these point to what is arguably a rather old-fashioned, modernist approach to relating the sciences to Christian theology—however up-to-date the scientific content may be.

Jeeves and Berry state that 'we are not philosophers or theologians'—but there are important philosophical and theological issues at the heart of their project. They set out some final 'guidelines for a constructive relation between science and faith' (there it is again!) (p.248–254), much of which may be affirmed without hesitation, but little of which directly addresses the kinds of questions raised in this article.

In sum, *Science, Life and Christian Belief* represents something of an end-of-century manifesto from two brethren within the UK science-and-Christianity 'establishment', and, given its scope, will no doubt become a standard text (like its predecessor). Nevertheless, for all its ostensibly evangelical atmosphere, it should be used with discernment, and different readers will probably find different sections particularly valuable—or particularly unconvincing.

Notes

1. From a perspective of my own *Reading the Mind of God* (Apollos, Leicester; 1958), published at the same time as *Science, Life and Christian Belief.*
2. My own brief trajectory through the philosophy of science ended with consideration of Michael Polanyi—who is not discussed by Jeeves and Berry (only listed in their bibliography). *Cf. Reading the Mind of God*, pp.124–136.

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Reviews

Green Eye of the Storm, by Prof. John Rendle-Short. The Banner of Truth Trust, 1998; 294pp. ISBN 0 85151 727 7. £9·95

Reviewed by J. H. John Peet

This book is the study of the lives of four scientists (Philip Gosse, George Romanes, Arthur Rendle-Short and the author himself) of four different generations who struggled with the evolution-creation debate. Yet, at the same time, it somehow seems to be the author's own pilgrimage. Because of his own experience, the author writes with sensitivity and with understanding and it is helpful reading for those with differing views of origins. The author describes a path many of us have taken and so we can read it with empathy.

Philip Gosse was a powerful voice in his generation who met intense opposition for his stand on the biblical account of special creation. Much of the material in the public domain comes from his atheistic son, Edmund, and so should be viewed critically. John Rendle-Short goes back to Gosse's own work to aid his evaluation.

Gosse was an outstanding naturalist of Darwin's own generation, but he saw things differently. Rendle-Short includes a review of the history of evolution theory and of the work of Lyell, essential to understand where Gosse was coming from. Gosse saw the dangers and wrote *Omphalos* as a counter. This is a book frequently referred to but rarely read. In it, he proposes the 'Law of Prochronism in Creation', that is that the cycle of life is repeated and Creation breaks into this cycle. This means that a mature creation will always have an appearance of age. Unfortunately this argument becomes extended to the presence of fossils in created rocks, a position better understood by modern creationists but this has led to much ridicule.

The second life history is that of George Romanes and is drawn from the writings of his wife. He came from a wealthy background and came under a strong evangelical influence at Cambridge. However, from the age of 22, he was plagued with ill-health for 20 years. He spent this time doing free-lance scientific research into invertebrate physiology. This led to him becoming a Fellow of the Royal Society in 1879. Reading Darwin's work had an 'extraordinary effect' on him. In turn, he wrote on vestigial organs for *Nature* journal. This was picked up by Darwin and resulted in a close friendship between the two, with Romanes being seen as Darwin's heir apparent. (Rendle-Short evaluates the work on vestigial organs from his own research and shows that it can now be discredited).

This relationship with Darwin led to his faith slipping away. However, in his last five years, we see him as a man slowly moving back to faith, firstly through a study of the ethical teachings of Christ and then by recognising design in nature. In the year before his death he suffered from a paralysis and set himself the task of facing the ultimate problems of life. His wife, Ethel, comments that in the last weeks there was a growth in holiness which only comes from a nearness to God. It seems that, in the end, he rejected the compromise between evolution and Christianity that many of his contemporaries had accepted.

Arthur Rendle-Short is the author's father. The older generation of modern Christians will remember this man of God with great affection. His academic prestige and humble Christian conviction were a source of strength to many young students. However, he struggled for many years quietly with an intellectual impasse: the apparent conflict between scientific evidence and biblical statements. By carefully studying his father's notes, John shows how his father struggled with the debate over many years, gradually shifting his ground, but always seeking to give his hearers an assurance that they could trust the Scriptures.

What comes out very clearly is Arthur Rendle-Short's humility, care, concern and love for Christ and His word. We see various indications of his shifting position. Back in 1913, he had written, 'It is we who are short-sighted. Truth can always afford to wait... The quest is not in vain.' In 1924 he spoke of 'no final solution' to the dilemma. By 1942 he is accepting microevolution but not macroevolution (*i.e.* the development of new species). He also queried the evidence of Piltdown Man. In the years 1947–1953, he is gradually developing his 'new idea' on the origin of life. In the notes of his final meetings, he appears to move to the biblical account and away from the evolutionary one. He was a man of his time, perplexed by evolutionary teaching and without the scientific answers which were to follow.

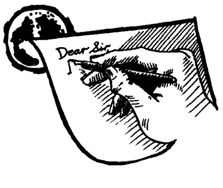
Finally we move to the author's own story. He describes his own confusion during his student days, noting the strengths and weaknesses of the Cambridge Inter-Collegiate Christian Union and the sociological effects of evolution theory. Like many others of his generation, he was deeply influenced by the work of Ramm and Pearce. However, he had two nagging problems: how could a creation by evolution be 'good' and what did one make of the Fall? Also, he wondered how one explained the origin of woman and still claim to be evangelical if we reject the biblical account.

As his story unfolds, he describes the position of the University and Colleges Christian Fellowship/Inter Varsity Press which prevented the publication (under its own imprint) of creationist works because of the influence of theistic evolutionists in its ranks. (The position was described as one in which the *Christians in Science* movement—to give its present name—claimed to be a theistic evolutionary body; this is not the actual case: it has never been a tenet of the movement and there are creationists in its membership).

Rendle-Short eventually came to accept the position of special creation in 1975/6. His pilgrimage to this position shows that creationism is not the result of uncritical thinking. The problems theologically and scientifically are real and must be confronted.

This is a book which is a pleasure to read and is instructive in seeking to understand how we have got into the present dilemma of conflict concerning the origin of life.

Correspondence



Victor S. Gilbert, Warwickshire.

It was indeed worth the wait to receive the latest *Origins* with its 'back to basics' of creationism. Your reiteration of a continuing commitment to scientific study complementing the study of the word of God is also very welcome and encouraging.

Joan Pilgrem, Surrey.

I think this issue (*Origins 27*) is excellent to give to friends who are non-scientific but intelligent.

Ken Jowett, West Sussex.

My congratulations to you on a splendid No. 27 issue. I only wish David Tyler's fine article on the *Quest for Human Origins* had gone that step further to which he refers in his final paragraph. I wish him well as he continues to seek a reconciliation between the Bible record and solutions apparently offered by the solely scientific approach. ... I was thrilled to read Andy McIntosh's article on the *Relevance of the Biblical Doctrine of Creation*. This for me was the highlight of the issue.

[*Editorial comment:* These are just a few of a significant number of comments received both in writing and verbally. We have a substantial stock of this issue and encourage members to purchase supplies for distribution.]

P. J. Wallis, N. Lincolnshire

I read the article by Steven Robinson ('Genealogy is not Chronology' in *Origins* No. 26) with interest and agree with the general trend of the author's argument. However, I feel he goes too far in indicating a period of around 18,000 years since the Flood (Figure 1 of the article). Population growth data suggests a much younger earth, *e.g.*

1. In *Bone of Contention*, page 28, Sylvia Baker reproduces a graph from *Population growth is a world problem* (HMSO), which shows that it would require only about 5,000 years to attain the present world population.
2. H. Enoch in his book, *Evolution or Creation* (Evangelical Press, 1976), compares growth in the worldwide Jewish population since Jacob's marriage with that of the total population of the earth. He takes the date of Jacob's marriage as 1930 BC and notes that the worldwide Jewish population in AD 1930 was 16 million. The latter is roughly 2^{24}, showing that the Jewish population has doubled every 161 years. Similarly, in 1965, the total world population was 2,500 million, roughly 2^{31}. From the Bible genealogies, H. Enoch puts the Flood at 589 years before Jacob's marriage (namely 2519 BC) when the post-Flood population was 23. Hence in the intervening 4483 years, the world population has increased by 2^{28}, doubling every 160 years.

The above examples suggest that, while the Bible genealogies may be incomplete, any omissions are of such a minor nature as to not seriously affect a date for the Flood of 2,500 BC to 3,000 BC.

Incidentally, I find it interesting that, in Fig.1 of this article, the author by implication accepts the pre-Flood Bible genealogy as a reasonably accurate chronology of that period.

[*Editorial comment:* This is one of a number of letters to this effect, querying the period of time suggested by Steven. We invited him to respond to these letters.]

Response from Steven Robinson

My article did not go into the reasons why a period of 18,000 years is the sort of timescale we should be envisaging—though I did say that they were primarily geological. The age of the post-Flood earth requires considering in the light of all relevant data, amongst which the data on population growth is perhaps of least importance. In this response I will try to give what can only be a very brief indication of the issues.

We know, roughly, how long the period was from the rise of Egyptian civilization to the present day, because historical data from that time allow us to measure its duration directly. What cannot be measured directly is the period before that, from the Flood to the end of the Stone Age. This has to be estimated by reference to geological and archaeological data.

The first step in such an exercise is to identify the Flood in the stratigraphic record. Among the crucial signs would be *(i)* evidence that the earth was totally under water, *(ii)* absence of organically colonised sea-floors or terrestrial surfaces, such as reefs, encrusted hardgrounds, *in situ* roots, animal tracks and burrows, since these could not have formed during a violent, global deluge and *(iii)* absence of any fossils of terrestrial animals for a substantial period following the rocks identified as diluvial, corresponding to the period when the earth was deserted except for where a small group of animals was beginning to radiate from the Ark. Since there was only one global deluge, there should be only one section of the geological record which meets these criteria.

Strange though it may seem, no modern diluvialist has sought to determine which part of the geological record might correspond with the Flood according to such criteria. Consequently, despite the forty years which have passed since Whitcomb and Morris's *The Genesis Flood*, there is a diversity of opinions in the creationist community concerning where the Flood began and ended, and not one has any scriptural or scientific credibility. The only part of the geological record which meets all criteria is in fact the very lowest part, from the Hadean to the end of the Archaean. For instance, only in the Hadean (when rocks do not seem to have formed at all) and earliest Archaean can it be argued that water might have covered the whole globe.

After the Archaean—and increasingly as one goes up the stratigraphic record—organic evidence of passing time abounds. Perhaps the most striking and easily appreciated

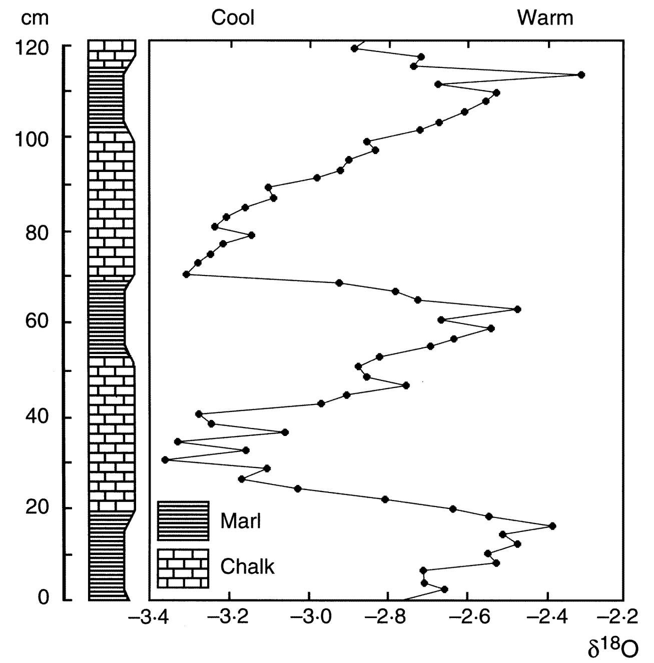


Figure 1. Chalk-marl couplets from the cliffs between Dover and Folkestone. The oxygen-isotope profile tracks the productivity of the organisms which produce the carbonate—high for shallow-water forams in the winter, high for deep-water and benthic (sea-floor) forams in the summer. The marls record an increasing proportion of summer-produced deep-water and benthic forams mixed with winter-produced clay. Because the clay particles took several months to pass through the water-column, they were deposited mostly in the summer. The carbonate produced in the winter and spring settled in the autumn and winter, after the clay.

example is organically formed reefs, which occur from the Precambrian onwards in every geological system. Often they are many tens of metres thick. A well-studied reef, extending over many kilometres, is that of the Canning Basin, western Australia (Devonian). The Carboniferous reefs overlooking Castleton, in Derbyshire, are another classic locality. Such structures may not have needed millions of years to form, but they certainly needed hundreds.

We are fast approaching the point where we can be more precise than that, however. For the later geological periods—even as far back as the Triassic—geologists have been gathering data that enable quantification of an absolute, non-radiometric timescale. This arises from the fact that many rocks preserve a cyclic pattern of sedimentation that is best interpreted as annual.

To give an example, Figure 1 shows an oxygen-isotope analysis of two chalk-marl couplets from a cliff in Kent (Ditchfield & Marshall, 1989). The ratio of ^{18}O to ^{16}O (expressed as δ^{18}O) in the carbonates is shown on the x-axis, with heavier concentrations to the right. The zig-zag pattern tracks a parallel cyclicity in rock composition, as limestone alternates with marl, and is typical of chalk formations in general. Indeed, the cycles can be correlated in chalk outcrops as far apart as the Crimea and southeast England (Gale *et al.*, 1999): approximately the same number of cycles can be counted over the same units of time, for hundreds of metres. Despite great weaknesses with the theory, conventional geology interprets the phenomenon as reflecting 'Milankovitch cycles': warm-cool cycles caused by changes in the precession of the equinoxes over 19,000 or 23,000 years and changes in the tilt of the Earth's axis over 41,000 years. So convincing is the cyclicity in the rocks that geologists are now beginning to 'fine-tune' their dates for the Cenozoic and its subdivisions to accord with this hypothesis.

However, there is an alternative explanation, based on the fact that very similar δ^{18}O cycles have been found to track the growth of calcium carbonate in individual shells and corals. Experiments have shown that the δ^{18}O ratio in the shell of the foraminifer *Globigerina bulloides*, for example, decreases as the amount of carbonate and carbon dioxide in seawater increases; in other words, higher concentrations of the heavier isotope correlate with higher temperatures (Spero *et al.*, 1997). In the case of the tropical foraminifer *Cyclobirculina compressa*, a species that inhabits the sea bottom, higher ^{18}O concentrations were found to coincide with lower temperatures (Wefer & Berger, 1980 and Figure 2). In either case, the cycles are clearly annual. Similar patterns have been detected in fossil shells (*e.g.* Purton & Brasier, 1999).

Both types of foram need to be considered when interpreting the chalk-marl couplets. As indicated in the table, the chalks contained a high proportion of forams (plankton) that floated near the surface, where sea temperatures were much warmer than lower down in the water column. Their lifespans were short—weeks rather than years. When they died, their microscopic shells sank to the bottom, a descent which, allowing for flocculation, is likely to have taken months. By contrast, the marls contained a high proportion of deep-water forams. Here there would have been a much shorter interval between death and burial, with the benthic (sea-floor) forams being buried *in situ*.

	Chalk	**Marls**
Clay content	low	high
% surface-water forams	high	low
% deep-water forams	low	high
Benthic diversity	low	high

Table 1: Analysis of foraminifers from the chalk/ marl couplets shown in Figure 1 (from Leary et al., *1990).*

The contrast in the life cycles of present-day *G. bulloides* and *C. compressa* probably has to do with the steep temperature gradient between top and bottom of the water column. At the surface, the levels of dissolved carbonate are low, because these are inversely proportional to water temperature, so that the optimal conditions for growth for calcareous organisms occur in the winter. This is also when nutrient levels are higher owing to increased run-off from the land. At the bottom, beyond reach of the sunlight, water temperatures are comparatively low throughout the year, so that the critical factor is not the amount of carbonate in the water but the effect of temperature on an organism's metabolism. Consequently, the season of greatest growth is the summer, when temperatures are higher. According to this explanation, the oxygen-isotope variation in calcareous organisms is fundamentally a function of growth rate, which may be related to temperature variation either directly or inversely, depending on the organism's

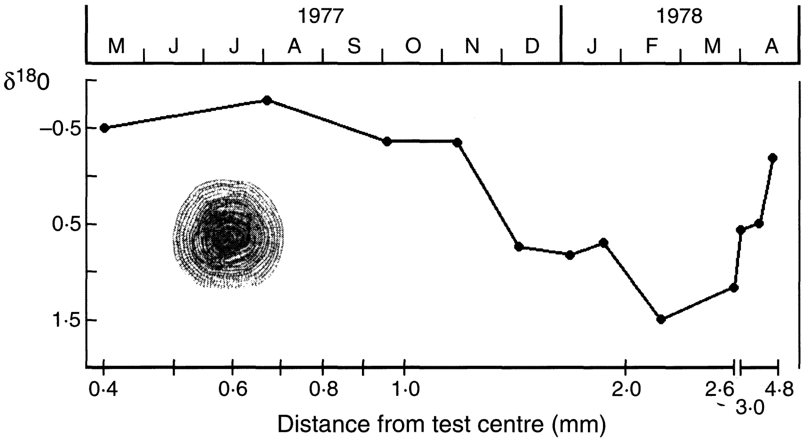


Figure 2. Oxygen-isotope variations in the benthic foraminifer Cyclorbiculina compressa *between May 1977 and April 1978. The horizontal axis shows distance from centre of test (shell) in mm, with the rate of growth higher in summer than in winter.*

habitat. Calcareous organisms incorporate a higher proportion of the lighter oxygen isotope from the surrounding seawater when they are secreting more carbonate.

If we apply these concepts to the Cretaceous beds, the chalk may be interpreted as accumulating in the autumn and winter from algae that bloomed in the winter and spring. By contrast, the organic component of the marl beds is composed chiefly of organisms whose growth season was the summer. The higher clay content represents sediment which was introduced in the winter, when rains increased the rate of terrestrial erosion, but which did not settle, this far offshore, until the summer. The ^{18}O-enriched carbonate within the marl is less voluminous than the ^{16}O-enriched chalk because foram productivity was higher in the warm, well-lit surface waters than deep in the water column. The sharp rises in ^{16}O concentration at or soon after the end of marl deposition represent condensed deposits (reduced algal production because of carbonate depletion coinciding with reduced run-off from the land).

Some creationists hold that the Flood ended at the end of the Cretaceous. Among them, Andrew Snelling attributes the rhythmic bedding analysed by Ditchfield and Marshall to 'rapid current flows' (1995). He postulates 'vast algal blooms almost filling the entire water column' in order to sustain the idea that chalk deposits hundreds of metres thick could have been laid down at the end of the Flood. The oxygen isotope evidence, he suggests, indicate 'pulses of warmer water'. However, the rhythmic beds do not suggest rapid current flows but quiet conditions, without which fine sediments could not settle out at all. Moreover, vast algal blooms cannot occur throughout the water column because, in order to photosynthesise and grow, algae require light and therefore inhabit only the upper zone. Thick clouds of algae would reduce the amount of light penetrating even the upper part, and in the quantities envisaged would require vastly more dissolved carbonate and carbon dioxide than the waters could hold—which would have become depleted as a result of the blooms. As for the oxygen isotope evidence, this does not indicate pulses of warmer water coming in from somewhere else, but oscillations in temperature in the same locality, with organisms growing both when the water is warm and when it is cool. Indeed, it is difficult to visualise such currents at all if at the same time algae have to be imagined blooming throughout the water column (to a depth of a hundred metres or more).

On the basis that alleged Milankovitch cycles in the geological record are really annual cycles, the length of the Cretaceous period alone would be some 3000 years. Consideration of cyclicity in other periods, and of other evidences which demand substantial periods of time (*e.g.* reefs, coals, changes in palaeogeography, the diversification of bivalves, ammonoids and dinosaurs, and so on) lead me to the conclusion that at least 20,000 years may have elapsed since the Flood. While many creationists will undoubtedly find it hard to give up the idea that the Flood occurred as recently as 2500 to 3000 BC, those who do will, I think, appreciate that this explanation of cyclicity in the stratigraphic record represents an immense step forward.

Population statistics do not constitute evidence for chronological purposes. If the population of Israel increased from 1930 BC to AD 1930 from 2 persons to 16 million, that is evidence only that in four millennia Israel's population increased from 2 persons to 16 million. It does not provide a logical basis for calculating an average rate of population growth and then applying that rate to a period for which we have no evidence about the rate of growth, because we do not know its duration.

If Israel's population had uniformly doubled every 161 years, then 966 years after Jacob's marriage—at the time of Solomon—it would have been around 130. Were the Flood to be dated to 2519 BC and world population to have doubled every 160 years, the total number of people in the world at the time of Jacob would have been about 100. Such figures illustrate the obvious point that population growth does not follow any mathematical formula but is dependent on culture, living conditions and historical contingencies (*e.g.* the Jewish Holocaust of this century, but also war, famine, disease and other natural disasters). Sometimes there are spurts of rapid growth, at other times populations may be stable or even in decline. The geological evidence indicates that the prehistoric period, from the Proterozoic to the end of the Pleistocene, was much longer than the historical period and punctuated by frequent natural disasters. That being the case, a low rate of population growth may be postulated.

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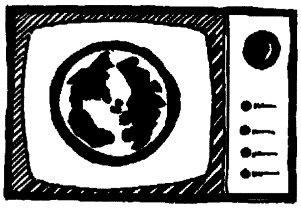
Creation in the News



New Planets

Astronomers have announced the discovery of nine new planets circling nearby stars. This brings to 50 the total number of known planets outside our solar system (called exoplanets). Of these, 41 were detected within the last five years. The pace of discoveries is such that, according to Professor Geoff Marcy of San Francisco State University, planet hunting has now become 'mundane'.

The discovery was announced at the International Astronomical Union (IAU) General Assembly in Manchester. Conference delegates were also informed of the second example of a star being orbited by more than one planet. Two Saturn-sized planets have been detected around the star HD 83443 in the constellation Vela. Before this, the only known system with multiple planets was Upsilon Andromidæ.

Inevitably, the media has speculated whether these planets might support extra-terrestrial life. The prevailing view is that life arose on the Earth by random processes in a primordial 'soup'. If it happened here, the reasoning goes, then perhaps it happened elsewhere in the universe too. This ignores the fact that we have no scientific basis for believing that it did happen here! The odds against the first organisms assembling themselves from a lifeless chemical 'soup' are staggeringly improbable. Life is special and, we have every reason to believe, unique to the earth.

Furthermore, the planets discovered so far are the wrong type to support life. They are gas giants like Jupiter or Saturn. They also have elongated, elliptical orbits; during their journey these planets pass very close to their star and also move very far away from it. Thus, any water on their surfaces would be alternately boiled and frozen. Clearly, this is not conducive to life! Nevertheless, Professor Marcy is confident that Earth-like planets must exist: 'It may be that our solar system is one in a hundred or one in a thousand, but let us not forget that our Milky Way galaxy contains one hundred billion stars so there are certainly Earth-like clones out there'.

Source: BBC News Online, 7 August 2000.
http://news.bbc.co.uk/hi/english/sci/tech/newsid_868000/868975.stm

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The price of a single issue is £3·00 plus postage. Origins 27 was a special issue with a price of £3·50 plus p&p.

Credits & Acknowledgements

The photographs on the back cover are by Steven J. Robinson.

ISSN 0953–2773

Designed and set by Langlands Edition

Printed by Inkon Printers, Oldham Street, Hyde, Cheshire SK14 1LL. Tel: 0161–368 3444

ORIGINS
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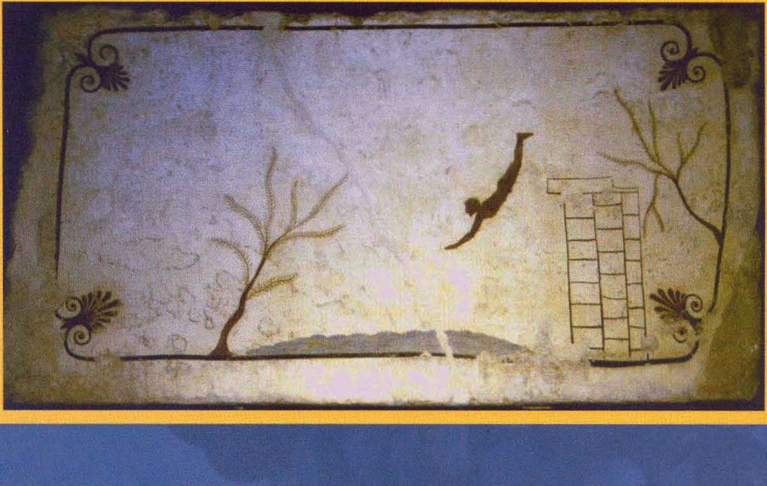

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